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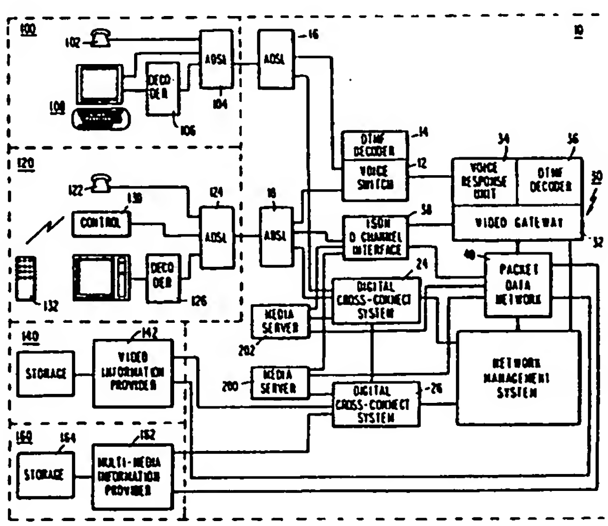



(57) Abstract

A media server (200, 202) receives, stores and forwards multi-media data and full motion video feature presentations within a PSTN. The media server (200, 202) receives wide band digital video and MPEG encoded video signals. The wide band digital video is encoded using either a real time MPEG encoding for immediate transmission over network facilities to subscribers (100, 120) or using a multi-pass MPEG encoder for storage by the Media Server (200, 202) for subsequent transmission. The Media Server (200, 202) includes DRAM (278), optical and magnetic disk storage (282), high speed tape storage (286) and archival storage (290). A Librarian Processor (250) allocates storage space on a media appropriate to retrieval requirements for the video data. The Librarian is responsive to a storage Manager Processor (270) and a Session Manager Processor (310) for providing video program data to an Output Controller (330).

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# MEDIA SERVER FOR SUPPLYING VIDEO AND MULTI-MEDIA DATA OVER THE PUBLIC TELEPHONE SWITCHED NETWORK

## Technical Field

The invention relates to a data storage distribution system using the Public Switched Telephone Network (PSTN), and, more particularly, to a media server for supplying stored image, video and audio data to local subscribers over a PSTN.

## Background Art

Video programming options have experienced rapid growth with advances in communications technology. Recent trends have been directed to user definition of programming, with each system subscriber specifying the programming to be provided. Such a system is described in related co-pending application Serial No. 07/766,535.

In addition to conventional full-motion video programs, advances in personal computer capabilities have created increased demands on data base sources to supply information to households and business. Corresponding increases in data availability, storage, retrieval and transmission capabilities have supported recent growth multi-media data presentation of information. Multi-media presentations include, in addition to conventional text, still-images, animation, slow and fast scan video, and graphics format visual

presentations. Multi-media also includes sound data presented in concert with, or independent of, one or more of the listed visual presentations. A multi-media presentation can range from the equivalent of an electronic book including plain test in combination with still images to full motion video presentations of feature movies. Thus, multi-media spans a wide spectrum of data storage, retrieval and transmission requirements to present information in various formats to system users.

As described, multi-media includes full motion video presentations. Various systems have been suggested to selectively provide a user with requested video programming. These systems are sometimes referred to as programming-on-demand and impulse pay per view. Monslow et al. U.S. Patents Nos. 4,890,320 and 4,995,078, respectively issued December 26, 1989 and February 19, 1991. These patents disclose a television broadcast system for real-time transmission of a viewer-chosen program at a viewer requested time to the requesting viewer's television receiver. The system comprises a program collection, which stores TV programs on a video tape. Each program is assigned and labeled with a catalog number.

A viewer request is transmitted using a conventional telephone over the PSTN to a scheduling computer. The chosen program is transmitted at the requested time over a broadband cable for viewing on the requesting viewer's television receiver. A control unit prevents other households connected to the cable from viewing the program.

Cohen U.S. Patent No. 4,949,187 issued August 14, 1990 describes a video communication system comprising a remotely controlled central source of video and audio

data. This system allows home viewers to select from a choice of movies or other video and audio data that may be transmitted from the central source to be stored at the viewer's premises. The viewer can play the selection at any convenient time of his choosing. The central source may store the data digitally. Movies that need to be frequently accessed are stored on disks. Movies that are accessed only infrequently are archived. A distribution system CPU controls the bidirectional flow of data from both types of drives. Several movies can be transmitted simultaneously to different users through a plurality of input/output controllers. To make use of a single transmission media, such as a telephone line, a multiplexer is used, which may multiplex in the time domain or the frequency domain.

Etra U.S. Patent No. 5,012,334, issued April 30, 1991 discloses a video image bank for storing a plurality of video image sequences. The bank provides a visual effects set for video production. The bank includes a library of video disks with an associated library index. A microprocessor is loaded with the library index. Groups of still frames, one from each identified image sequence, are displayed and an operator selects any one of the represented image sequences for addition to an edit tape and associated edit list prepared by the bank.

Ciampa et al. U.S. Patent No. 4,635,136, issued January 6, 1987 discloses a massive inventory of labeled images, which are stored in a digital form. A TV signal for each image is generated by a video camera. Stored digital information defines the route for a video camera to each site where a video image is recorded.

<u>Lambert U.S. Patent No. 4,381,522</u>, issued April 26, 1983 discloses a cable television system which includes a plurality of selectable video signal sources having selectable television program material. The system enables a viewer to select desired program material available by telephone at a remote location and have the selected material promptly available for viewing. A minicomputer stores information on the program source location, the status of the selected program source, the available channels and the schedules for each.

<u>Walter et al. U.S. Patent No. 4,513,390</u>, issued April 23, 1985 discloses an information system for storage, retrieval and generation of information from a plurality of multi-media sources. The system uses a plurality of source inputs and a plurality of data outputs, all under the control of a common computer that is operative along a common data bus. Included as source inputs are stored memory data, hard copy, microfiche and direct operator entered data.

<u>Pocock et al. U.S. Patents Nos. 4,734,764 and 4,941,040</u>, issued respectively on March 29, 1988 and July 10, 1990 disclose cable TV systems for distributing pre-recorded video and audio messages, which comprise a remote storage device. The video is presented as still frames, which are stored in a multiple node frame store. A video frame has one of the scan lines in its video blanking signal uniquely addressed.

<u>Nakajima et al. U.S. Patent No. 4,538,176</u>, issued August 27, 1985 discloses a video/audio transmission system, which sends video and audio information from video and audio files at a center to a subscriber

through at least one subcenter having a video/audio buffer memory.

Walter U.S. Patent No. 4,506,387, issued March 19, 1985 discloses a programming-on-demand cable system, which allows any one of a plurality of users to request any one of a plurality of video programs from a library of programs. The programs are stored in memory devices selectable by a host computer at a central data station in response to an address signal transmitted from the user. Upon request of the viewers, the programs are transmitted at a high non-real-time rate over a fiber optic line network. Optical data is then reconverted to electrical data and stored for broadcast to the viewers.

McCalley et al. U.S. Patent No. 4,829,372, issued May 9, 1989 discloses a presentation player which is utilized in a digital, interactive communication system accessible to a plurality of subscribers who can select any of a plurality of pre-recorded video/audio presentations for viewing on their TV sets. The system includes a large scale data base, which stores digital information including still frame images and textual information in hard disk memory units.

Beaulier U.S. Patent No. 4,821,121, issued April 11, 1989 discloses a still image store system, which stores and selectively outputs video image data. A random access frame store receives input video data converted into digital form and transfers the data to a disk store for more permanent storage. Full size data and reduced size data of the same video image are stored.

Bohn U.S. Patent No. 4,888,638, issued December 19, 1989 discloses a marketing research system for substituting stored TV programs for regularly

scheduled, broadcast TV programs. The substitute TV programs may be transmitted from a central office via telephone lines to households of cooperating panelists for storage at the household premises.

While providing multiple data formats from a data base to a user, these prior art systems do not integrate network control functions to provide a high speed data link between major nodes narrow band encoded data from nodes to remote users. In particular, prior art systems are not responsive to individual user requests for providing high speed data connectivity from a data source to a node serving one or more users and selectively scheduling and supplying requesting users with programming.

Related copending application serial number 07/766,535 filed September 27, 1991 describes Video-On-Demand (VoD) Services that provide video programming to subscribers over the public switched telephone network (PSTN). A menu of video programming information is accessible at the subscriber's premises. The subscriber may transmit ordering information via the PSTN to independent video information providers. Video programming may be accessed and transmitted to the subscriber directly from a video information provider (VIP) or through a video buffer located at a central office (CO) serving the subscriber.

The VIP transmits coded digital video data over wideband PSTN supplied connectivity to a central office. The video data may be buffered at the central office for transmission over a POTS line to the subscriber. A subscriber may use either a standard telephone instrument over the PSTN or a dedicated control device over an ISDN packet network to order the video programming. Such a device is located at a

television set of the subscriber and permits a display of the program menu on the television screen.

Connectivity between the central office and the subscriber for transmission of video data is provided by an asymmetrical digital subscriber line (ADSL) system. ADSL interface units perform frequency multiplexing of digital video information with voice information to be transmitted to the subscriber and support transmission on the ISDN packet data network of a reverse control channel from the subscriber to the central office.

However, the Video-on-Demand system does not include an integral library of video program material, nor does it support integration of several sources of programming material to provide a multi-media or mixed media presentation. The VoD buffer includes limited storage capabilities for video and audio data supplied by a VIP. Enhanced functionality is required to support multiple program storage and to integrate data from various data bases to provide composite programming required for multi-media and mixed-media presentations.

To support network management, a need further exists for a system which dynamically interacts with network facilities to reconfigure network resources in real-time and in response to information requests. A further need exists for a library system for accessing and retrieving multi-media programming from storage and from independent information providers in response to user requests and transmitting the data over wide bandwidth links to a node serving a user.

Accordingly, an object of the invention is to provide a library of multi-media data including video programming on demand using components of the PSTN.

Another object of the invention is to provide subscriber access to multiple sources of combined image and textual programming over the PSTN.

Still another object of the invention is to provide real-time subscriber control of multi-media and video programming delivery.

A still further object of the invention is to provide a selected video program to a subscriber within a predetermined short processing interval after initiation of a request.

Disclosure of the Invention

According to one aspect of the invention, a media server for supplying multimedia data includes a user request processor responsive to a user request for supplying information request data. A session controller is responsive to the information request data for supplying information retrieval data and output control data. A data storage device is responsive to the information retrieval data for supplying program data. An output controller, responsive to the output control data, supplies the requested multimedia data. The multi-media data may include text, still images, graphics, low and high resolution partial and full motion video and audio.

The output controller includes transmission circuitry for transmitting the multimedia data to remote end users. According to a feature of the invention, a public switched telephone network is responsive to the output control data from the session controller for supplying the multimedia data to remote end users. The user request data is supplied to the user request processor means by the public switched telephone network.

According to another aspect of the invention, the user request processor includes a transmission receiver for receiving the user request data from a remote end user. The user request data is supplied to the transmission receiver by a public switched telephone network.

In accordance with another aspect of the invention, the data storage device includes a plurality of storage media for storing the program data. The data storage device may include both optical and magnetic memories and may further include three different storage media having substantially different respective information retrieval times.

According to another aspect of the invention, session manager includes an output port selector responsive to the user request data for supplying output port assignment data and a memory for storing session status data. The memory includes a table for storing output port assignment data, input port assignment data, and program status data.

According to another aspect of the invention, the media server includes a program storage librarian responsive to the information retrieval data for supplying program priority data of respective program data, the data storage device responsive to the program priority data for storing the program data.

According to another aspect of the invention, a random access storage unit provides storage of the program data.

According to another aspect of the invention, a program data input controller is responsive to the session controller for supplying real-time program data to the data storage device. A video data encoder receives the real-time program data and supplies

encoded video program data to the data storage device and/or to the output controller for immediate distribution.

According to another aspect of the invention, the session controller includes session registers for storing dynamic frame location data indicating a current frame position of the program data. The session controller may further include a memory for storing a session routing table having program data routing data and program source data for active users.

According to another aspect of the invention, the session controller is responsive to user address and file selection data for supplying network configuration request data. The user request processor may include security processor for storing user access data and, responsive to the user access data, selectively supplying the information request data to the session controller.

According a feature of the invention, the user request processor can detect a user control link failure. The user request processor may further include an audio response unit for receiving the user request data and for supplying audio responses to a requesting user and a program catalog processor responsive to the user request data for supplying the program catalog data to a requesting user.

According to another aspect of the invention, the user request processor means supplies the user request data to a multi-media processing means for supplying information retrieval data to the data storage means.

The media file server system handles requests received from a Video Services Gateway and provides a video file feed to the customer via the network link. In addition to Video-on-Demand capability, the server

supports other user highly interactive multimedia applications. The server is a file management system responsible for inputting video files from video and multimedia information provides storing these files or passing the real-time data through to the user, keeping track of the user's session, handling all interactive control requests from the user, and controlling all output to the user.

The system comprises an input controller, Q.931, X.25, T1 and DS-3 interfaces, a librarian, a storage manager, a session manager, an output controller, an interactive processor, and a multi-media application processor. The librarian provides file functions including distribution of video, audio, stills, and text selections to the session manager and the multi-media application processor at the request of itself and the multimedia application processor. The librarian keeps track of the storage location of all multimedia selections and catalogs and stores all incoming files from VIPs. The librarian records access history for determining statistical usage and trends. This information is used for, among other things, designating frequently used features for assignment to rapid access highly addressable storage. Various storage modules of differing capacity and access speed are provided.

Storage format is MPEG encoded digital video, received from the VIPs, or D1 digital video, which is MPEG encoded by the server processor and stored in MPEG format. The processor provides appropriate interface with intelligent protocol.

The above and other objects, features and advantages of the present invention will become

apparent from the following description taken in conjunction with the accompanying drawings.

## Brief Description of Drawings

Figure 1 is a block diagram of a multi-media programming distribution system including a media server according to the invention integrated in a public switched telephone network.

Figure 2 is a simplified block diagram of a media server according to the invention.

Figure 3 is a detailed block diagram of a media server according to the invention.

Figure 4 is a block diagram of program storage facilities of the media server according to the invention.

## Best Mode for Carrying out the Invention

The overall Video-on-Demand and Multi-Media distribution service platform shown in Figure 1 uses existing components of the Public Switched Telephone Network (PSTN). The system supports storage and distribution of conventional full motion video programs ("features") such as movies at user request, i.e., Video-on-Demand (VoD). Also supported are Multi-Media presentations and processing, including combinations of text, still images, and full and partial motion video. Video may include interactive activities such as training applications, games, shopping, etc.

The Media Server uses compression techniques to store video and other multi-media data in memory resources controlled by the Media Server for subsequent forwarding over interoffice facilities. The switching facilities are located in Central Offices (COs) serving residential customers or subscribers. Loop electronic

devices modify the transmission characteristics of the local copper loop, to provide required enhancement to the PSTN and permit delivery of full motion video information and other media.

High data rate types of multi-media data are encoded to conserve system resources. For example, analog video information is first converted to a digital format using encoding algorithms standardized by the International Standards Organization (ISOs) Motion Picture Experts Group (MPEG). Each title comprises video information stored by the Media Server as an addressable data file in conventional data processing devices functioning as a video library. The function of establishing and monitoring connections linking a video library port transmitting selected information with the end user ports receiving the information is performed by a supervisory controller such as a network control system, e.g., FLEXCOM software, used to control the electronic digital cross-connect switches (DCS) in the PSTN. The DCS, also used for switching two-way DS-1 rate transmissions, is adapted to additionally provide bridging or broadcast of video information to several users. Data session control between a video library port and a remote user one of the functions performed by the session manager of the Media Server.

The network control software of the Media Server in combination with management resources of the PSTN (i.e., FLEXCOM/LINC or other Network Management System) control the "network session" between an Output Controller of the Media Server, external program providers, and user ports. The session manager also maintains a record of relevant data regarding each

session which is forwarded to a customer billing system.

Customer local loops equipped with Asymmetric Digital Subscriber Line (ADSL) devices are connected to the DCS. The multi-media distribution system provides for the simultaneous transport of a one-way 1.544 megabit per second (MBPS) signal over the same twisted pair transmitting voice messages to the residential subscriber. The ADSL transported signal is demultiplexed and the 1.544 portion is then decoded using MPEG standard techniques to deliver a full motion video signal. In the PSTN, fiberoptic technology will replace existing coaxial and twisted pair connectivity with corresponding enhancements made to switching and routing equipment.

Referring to Figure 1, a multi-media system includes CO equipment 10 which is part of a PSTN. CO 10 provides connectivity from information providers 140 and 160 through the system to Media Servers 200 and 202 to Multi-Media subscriber 100 and VoD subscriber 120.

CO equipment 10 includes a conventional voice switch 12 which includes means to detect off-hook, service requests, call completion (i.e., ring trip), a DTMF decoder 14 and dial pulse detector. Voice switch 12 also includes an actual telephone call connection switch for routing voice circuits among the various ports. The CO equipment shown may be physically distributed over several sites.

Connected to voice switch 12 are ADSL equipment 16 and 18 for multiplexing (i) voice and signaling information from voice switch 12 and (ii) digital multi-media data from Digital Cross-Connect System (DCS) 24 onto respective subscriber local loops 20 and 22. Multi-media data from multi-media information

providers 140 and 160 is provided to DCS node 26 where it is selectively supplied to Media Server 200 or immediately transmitted to DCS node 24 under control of Network Management System 28.

In addition to providing pre-stored video and multi-media programming, the Media Server accepts video and multi-media programming from video and Multi-Media Information providers 140 and 160 for later transmission and for real-time and multi-pass MPEG encoding. Real-time encoding is used to provide encoded full motion video while minimizing network transmission requirements and providing a signal compatible with ADSL connectivity to subscriber premises 100 and 120. Multi-pass encoding performed by the Media Server provides a higher quality video signal for storage and later transmission over the network to subscriber premises 100 and 120.

ADSLs 16 and 18 multiplex data on subscribers loops 20 and 22 using frequency multiplexing, dividing the available loop bandwidth into three segments. Base band audio and signaling below 4 kilohertz (kHz) provides connectivity for a conventional telephone services available on the "plain old telephone system" (POTS). Alternatively, ISDN channel requirements consume the bottom 80 kHz of loop bandwidth. Reverse channel digital packet information is positioned between 80 and 90 kHz providing approximately 16 kilobits per second (kbps) connectivity from the subscriber premises to a packet switched network such as ISDN network over a D-channel interface. Compressed video and multi-media data is contained between 100 and 400 kHz to provide a 1.6 MBPS channel for transporting the video and multi-media data over respective loops 20 and 22 to customer premises 100 and 120.

The Media Server is shown in further detail in Figure 2. The Media Server system processes all requests from Video Gateway 30 for providing multi-media and video file feeds to customer premises via the DCS and ADSL systems. The Media Server preforms input of video and other information files from Video Multi-Media Information providers 140 and 160, stores these files or passes real-time data through to subscribers 100 and 120, monitors and records user sessions, processes all interactive control requests from users, and controls all output to the user.

The Media Server also processes and supplies multi-media services including interactive learning, interactive games, and other presentations. The Media Server stores and processes all data required for the multi-media applications including text, still pictures, audio, and partial and full motion video, as well as interactive application scripts.

The Media Server includes eight major component systems: Input Controller 210, Q.931 ISDN Interface 230, Librarian 250, Storage Manager 270, Session Manager 310, Output Controller 330, interactive processor 350 and multi-media application processor 370.

Input Controller 210 includes a plurality of DS-3 Input Ports 212 for receiving multi-media data including digitized video in the form of MPEG encoded digital video signals and unencoded video. D1 digital video is supplied to Librarian 250 for MPEG encoding. Video supplied in MPEG encoded format is supplied to Session Manager 310 for storage by the Media Server or for immediate transmission by output controller 330.

Q.931 Interface 230 provides connectivity between Interactive Processor 350 and ISDN D Channel Interface

38 (Figure 1). Interactive Processor 350 receives command data over the ISDN from subscribers running interactive programming from the Media Server. Interactive programs include Multi-media presentations and video games. Interactive Processor 350 also receives command data from subscriber control unit 130 for interactive control of feature presentations (i.e., conventional video programming including movies, concerts, etc.) including pause, fast-forward, reverse, and other "VCR" type capabilities supported by the Media Server. These latter commands are passed to Session Manager 310 for further processing and control of the video programming.

Data to be stored or retrieved from memory is first routed through Librarian 250 and, under its control, Storage Manager 270 either stores the program data or retrieves and provides previously stored program data to Output Processor 330.

Media Librarian 250 controls distribution of video, audio, still image data and text selections to Storage Manager 270 in response to information requests from Session Manager 310 and Multi-Media Application processor 370.

Referring to Figure 3, the Librarian further monitors and record in Feature Index System 252 the storage location of all video selections for VoD and Multi-media applications. The Librarian also records a history of access to video programming, i.e., "features", and to other data provided during each twenty-four hour period in Usage Data Accumulation System 260. The usage data is supplied to Usage Probability Processor 262 to establish an intelligent cache using DRAM Storage 278 for rapid access and highly addressable storage of features.

Feature Index System 252 maintain a catalog of data and support processing for storing all locally stored programs. This includes the allocation of storage media type and space, maintenance of addressing tables for program status and frame indices, and maintain an index for all volumes. The program listing data is supplied to a menuing system supported by Video Gateway 30 (Fig. 1) via Packet Data Network 40.

Feature Index System 252 performs catalog maintenance functions including input of new feature program data into the system, ageing, and deletion or archival of aged program data. New program data from Video and Multi-Media Information Providers to be stored by the Media Server are received via a DS-3 port 212 of Input Processor 210. The catalog maintenance system determines the priority of the incoming program data and allocates appropriate storage to the data. Once the file space is allocated and the file is stored, the volume indexes are updated, the frame positions of the program are calculated and frame addressing tables are created and stored. The frame addressing tables are used to address a feature from any position in the feature.

When it is determined that a stored feature is no longer required, Media Librarian 250 removes the program data from the file catalog. The record to be deleted is then flagged by a system administrator of Storage Allocation Processor 272.

Librarian 250 tracks frequency of feature access. As a feature is requested less frequently, it is "aged" by the Media Server. Usage Probability Processor 262 assigns a priority value to the feature which is used to determine the appropriate storage type to maximize system resources while providing acceptable access time

to th_ feature based on its demand history. Once a feature is aged to a point of not having been requested within a predetermined time period, the Media Server removes the program from on-line storage units 278, 282 and 286 and places it in archival storage 290. The feature header data remains stored in Feature Index 252, although access time for the feature will be increased.

The catalog system updates feature titles data as the features are loaded into the Media Server. The updated catalog information is supplied by Librarian 250 of the Media Server to Video Gateway 30. The data supplied to the Video Gateway is shown in Table 1.

| ELEMENT | USE | ORIGIN | TYPE |
|---|---|---|---|
| Feature Title | To be used by the menu system to update the list of features provided for the users. | Video information provider or programmer | |
| Feature Index Number | Used by the Gateway when transmitting a request to the server. | Librarian | Alpha/Numeric |
| Priority | Used by the Gateway to determine the set-up and wait time for a feature. | Originally determined by the feature box office ranking. Subsequently determined by the Trend processor. | Integer |
| Feature Length | Used for schedule processing by the Gateway. | | |
| Key Actor/Actress, Author, Director, Subject | Used by the Gateway for performing searches on the elements listed. | VIP | Array |
| Motion Picture Association Rating | Used by the Gateway for feature type blocking based on rating: G, PG, PG-13, R, NC-17, XXX | VIP | |
| Category | Used by the Gateway Menu processor to determine the placement of the title. | VIP | |

TABLE 1

Alternatively, according to a preferred embodiment of the invention, menu data is retained in the Media Server and downloaded to user customer provided equipment (CPE) for viewing and selection or transmittal to the user directly for processing.

Usage Probability Processor 262 statistically determines features having the highest probability of usage on a per hour and day of week basis to properly allocate high order storage, i.e., DRAM Storage 278, on an hourly basis. In support of this function, Usage Data Accumulation Memory 260 stores tables of data including time of viewing, day of viewing and cumulative number of requests that are updated each time a feature is supplied.

Allocation of storage in the Media Server is based on the ranking of a feature and the output of the trend processing performed by Usage Probability Processor 262. Referring to Fig. 4, storage is divided into several components, including DRAM 278, Magnetic Tape 290. All features are stored on the appropriate media based on the priority ranking of the feature. For example, DRAM Storage 278 is used for the highest priority features as determined by the trend processing whereas Archival storage is used for the lowest priority features. Table 2 gives typical priority assignments and storage capabilities of each media.

| PRIORITY | NUMBER OF FEATURES | STORAGE |
|---|---|---|
| 1 | 20 ± 5 | DRAM |
| 2 | 100 ± 3- | MAGNETIC DISK |
| 3 | 300 ± 50 | HIGH SPEED TAPE |
| 4 | 500 + | ARCHIVAL TAPE |

TABLE 2

DRAM Storage 278 is used for the highest twenty features and data files as determined by the trend processing. When a feature or other high priority media file is stored in DRAM it does not occupy magnetic storage space until removed from DRAM storage. A compressed feature length movie of 90 minutes duration occupies approximately 1.2 gigabytes of DRAM storage.

Disk Storage Units 282 are fast access magnetic and/or optical media providing storage for the second highest fifty priority features and media data files as determined by the trend processing. When a feature is stored on a Disk unit, it does not occupy DRAM or Tape Storage until removed.

High Speed Tape Storage Units 286 store features and multi media data files having a medium priority as determined by the trend processing. Finally, Archival Tape Storage is used for the lowest priority features and media data files.

Storage Channel Management Processor 274 controls flow of data between all storage devices and Output Control Processor 330. Input Control Processor 210 receives multi-media and feature program data from Video and Multi-Media Information Providers 140 and 160. Feature data input streams are accepted either as MPEG encoded digital video or as D1 digital video to be encoded by the Media Server. All data is either stored for play at a users request or passed directly through to the user as real-time programming.

MPEG encoded video data received at DS-3 port 212 of Input Processor 210 is routed to Session Supervisor

312 for storage by the Media Server or as flow-through to an appropriate output port 332 of Output Processor 330. Session Manager 310 supervises the data flow once connection from the Video Multi-Media Information Provider to the subscriber is established by Input Control Processor 210 and Output Processor 330. No data is stored and no index information is supplied to Librarian 250 in the case of flow-through data.

For non-encoded data, a simplified form of MPEG encoding is performed by Real-Time MPEG Encoder 390, requiring a latency of approximately ten minutes from data input to data output. Multi-Pass MPEG Encoder 392 is used for non-real-time processing, and provides full MPEG encoding of video data. Both MPEG encoders receive non-encoded video data from Input Processor 210 and provide encoded video to Storage Allocation Processor 272 of Storage Manager 270. The encoded video data is either stored in an appropriate storage media or transmitted by Storage Channel Management Controller 276 to Output Controller 310 for transmission to a subscriber over the PSTN.

Session Manger 310 include Session Supervisor 312 which manages all program sessions including system access by Video-on-Demand subscribers, other Multi-media users and input and output to, from and through the Media server by Multi-Media Information Providers. Session Supervisor 312 tracks and records all data pertinent to each session including output port, input port (if receiving data directly from a Multi-media Information Provider or if the user is a Multi-media Information Provider), feature being played or Multi-media application address, feature index data, feature frame data, and session condition. The Session Supervisor also performs network resource optimization

by the simultaneous broadcast of the same feature over one output port to multiple subscribers. However, each subscriber session is individually managed to permit interactive features such as video pause.

Session Trace Processor 314 tracks each subscriber's session based on feature and frame so that the execution of a pause sequence can be managed for each individual session. A subscriber may start viewing a feature as part of a larger group, with a subsequent selection of a pause function placing the subscriber "out of sync" with the rest of the group. Once out of sync, a separate session is established for that user requiring Session Manager 310 to cause the Gateway to establish a new network link to the subscriber's viewing location. Note that, although each user is assigned an individual logical session, sessions remaining in sync with each other share output and network facilities.

Session Supervisor 312 maintains a matrix of routing information for each session, including what users are assigned to a given output port, and the source of the input data: Input Port number or local storage location in use. A file play clock uses the total number of frames in a given feature to estimate, by time, the frame position for that feature. This data is provided to the Session Registers 316 for tracking frames for each logical subscriber session and is used to restart an interrupted session. Session Supervisor 312 discontinues register updates upon detection of a session interruption. The Session Manger 312 receives requests for initial session establishment and for file retrieval from Gateway 30 via Q.931 Interface 230 and Control Channel Filter 354.

Interactive Processor 350 processes incoming commands from subscribers sites once a session is established by the Gateway. These commands include pause or like feature for Video-on-Demand, and all response and requests by Multi-Media work stations. The incoming data is interrogated for content and selectively forwarded to the appropriate module for processing: Session Manager 310 for Video-on-Demand and other retrieval applications and to Multi-Media Application Processor 370 for Multi-Media Applications.

Control Channel Monitor 352 monitors each subscriber's control channel to detect a communication failure. In the event of a failure, Session Manager 310 is informed and corrective action is initiated.

Referring to Fig. 1, dial-up access to the Media Server in the absence of dedicated Control Unit 130 is provided by voice switch 12 which establishes connectivity with VRU 34 which answers the incoming call. The VRU prompts the subscriber for a user ID which is input via the DTMF pad of telephone instrument 122. The user ID is checked and, if valid, the VRU prompts for a video selection. The video selection is then input using the DTMF pad of telephone instrument 102 which then sends the selection information to the Media Server via Video Gateway 32 and Packet Data Network 40. The Media Server identifies the requested title and determines if the title is available.

If the title is found, and has not been previously queued for transmission, the corresponding data file is opened and a reserve idle communications port is identified for transmission of the video data to an associated DCS node 24 or 26. Transmission of the data is delayed for a predetermined number of minutes in response to a first request for the video selection to

allow for simultaneous transmission of the video data file to subsequent subscribers placing an order for the same title within the delay period. The subsequent request orders are also placed in the queue and the associated communications port ID is matched to the subscriber's network address.

After expiration of the predetermined delay, i.e., when current time equals the designated start time, the video data file is transmitted from Media Server through the DCS to the designated ADSL interface 18 for transmission to subscriber premises 120. At the end of the program, a message is transmitted by the Media Server to Network Management System 28 to take the system down by terminating DCS connectivity.

In an enhanced version of the Video-on-Demand system, subscriber premises 120 (Figure 1) is provided with a control unit 130 for receiving data commands from remote control 132. Remote control 132 can be a conventional infrared remote control for interacting with control unit 130. Data from control unit 130 is provided to subscriber ADSL interface 124 for transmission of command data to ISDN D-channel interface 38. The ISDN D-channel interface can provide initial subscriber order information directly to video gateway 30 in lieu of using voice response unit 34. Once video gateway 32 identifies a subscriber request to establish connectivity with the Media Server, the address of control unit 130 is provided to the Interactive Processor 350 (Fig. 3). Upon receipt of the corresponding Interactive Processor network address by control unit 130, direct connectivity is established between control unit and the Media Server 200 or 202 over packet data network 40. This connectivity permits direct data transfer between the customer premises and

the Media Server to support interactive video control used in interactive educational programming and interactive video presentations such as video games.

Control unit 130 also supports interactive control of the buffered video data by transmitting appropriate commands to Session Manager 310. These controls allow the subscriber to fast forward, rewind, forward, reverse search and pause the video/audio data provided via DCS 24 to the subscribers premises.

VRU 34 may additionally include voice recognition capability to support voice recognition security functions and voice selection of video programming.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration an example and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by terms of the appended claims. For example, MPEG encoding may be performed by an attached processor that is part of the server architecture. Further, each component of the server architecture may reside on a separate processing platform and be closely coupled by high speed application program interfaces (APIs).

## Claims

1. A media server for supplying multimedia data, comprising:

means for processing user request data, said user request processing means being responsive to user request data for supplying information request data;

means for controlling sessions of said media server, said session control means being responsive to said information request data for supplying information retrieval data and output control data;

data storage means responsive to said information retrieval data for supplying program data; and

means for controlling the output of said media server, said output control means being responsive to said output control data for supplying said multimedia data.

2. The media server according to claim 1 wherein said output control means comprises transmitting means for transmitting said multimedia data to remote end users.

3. The media server according to claim 1 further comprising a public switched telephone network responsive to said output control data from said session control means for supplying said multimedia data to remote end users.

4. The media server according to claim 3 wherein said user request data is supplied to said user request processing means by said public switched telephone network.

5. The media server according to claim 1 wherein said user request processing means comprises transmission receiving means for receiving said user request data from a remote end user.

6. The media server according to claim 5 further comprising a public switched telephone network for supplying said user request data from a remote end user to said transmission receiving means.

7. The media server according to claim 1 wherein said data storage means includes a plurality of storage media for storing said program data.

8. The media server according to claim 7 wherein said data storage means includes optical storage means and magnetic storage means.

9. The media server according to claim 7 wherein said data storage means includes three different storage media having substantially different respective information retrieval times.

10. The media server according to claim 1 wherein said session management means includes:

output port selection means responsive to said user request data for supplying output port assignment data; and

memory means storing session status data.

11. The media server according to claim 10 wherein said memory means of said session management means includes table means storing output port

assignment data, input port assignment data, and program status data.

12. The media server according to claim 1 further comprising program storage librarian means responsive to said information retrieval data for supplying program priority data of respective program data, said data storage means responsive to said program priority data for storing said program data.

13. The media server according to claim 1 further comprising a random access storage unit for storing said program data.

14. The media server according to claim 1 further comprising program data input control means responsive to said session control means for supplying real-time program data to said data storage means.

15. The media server according to claim 14 further comprising video data encoding means receiving said real-time program data and supplying encoded video program data to said data storage means.

16. The media server according to claim 14 further comprising video data encoding means receiving said real-time program data and supplying encoded video program data to said output control means.

17. The media server according to claim 1 wherein said session control means includes session register means storing dynamic frame location data indicating a current frame position of said program data.

18. The media server according to claim 1 wherein said session control means includes memory means storing a session routing table having program data routing data and program source data for respective active users.

19. The media server according to claim 1 wherein said session control means is responsive to user address and file selection data for supplying network configuration request data.

20. The media server according to claim 1 wherein said user request processing means includes security means storing user access data and, responsive to said user access data, selectively supplies said information request data to said session control means.

21. The media server according to claim 1 wherein said user request processing means includes means for detecting a user control link failure.

22. The media server according to claim 1 wherein said user request processing means includes an audio response unit for receiving said user request data and for supplying audio responses to a requesting user.

23. The media server according to claim 1 wherein said user request processing means includes program catalog data storage means responsive to said user request data for supplying said program catalog data to a requesting user.

24. The media server according to claim 1 further including a multi-media application processor, said

user request processing means supplying said user request data to said multi-media processing means and, in response, said multi-media processing means supplying said information retrieval data to said data storage means.

25. In a public switched telephone network (PSTN) for providing multi-media data to one of a plurality of subscriber premises, including a cross-connect system responsive to control data for establishing connectivity between a multi-media data base and said subscriber premises, the improvement comprising:

a media server for supplying said control data and supplying said multimedia data, including

(i) means for processing user request data, said user request processing means responsive to user request data from the PSTN for supplying information request data,

(ii) means for controlling sessions of said media server, said session control means being responsive to said information request data for supplying the control data to the cross-connect system and supplying information retrieval data, and

(iii) a multi-media data base responsive to said information retrieval data for supplying the multimedia data to remote end users.

26. A media server for supplying full motion video data, comprising:

means for processing user request data, said user request processing means being responsive to user request data for supplying information request data;

means for controlling sessions of said media server, said session control means being responsive to

said information request data for supplying information retrieval data and output control data;

data storage means responsive to said information retrieval data for supplying program data; and

means for controlling the output of said media server, said output control means being responsive to said output control data for supplying said full motion video data.

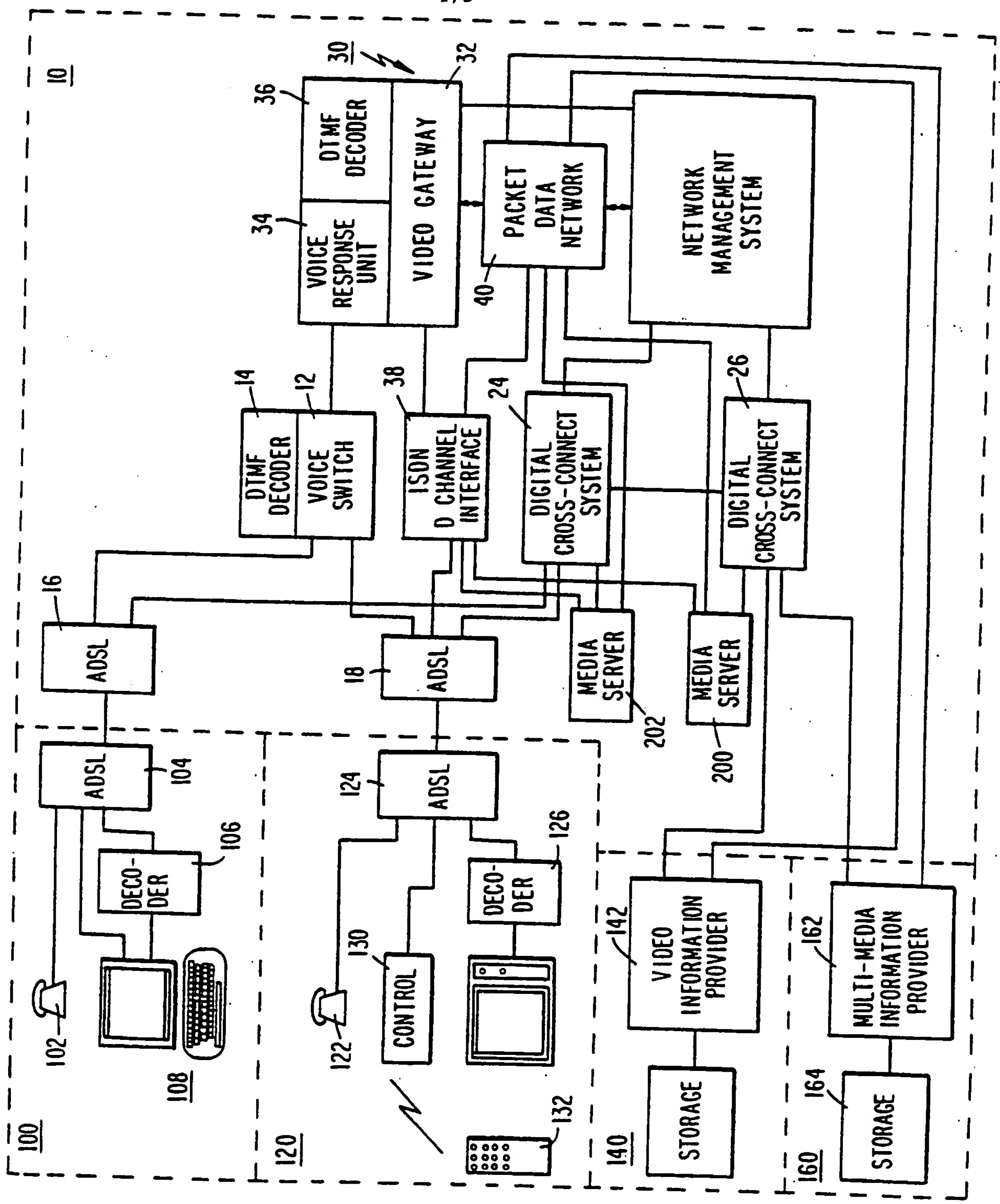



FIGURE 1

SUBSTITUTE SHEET

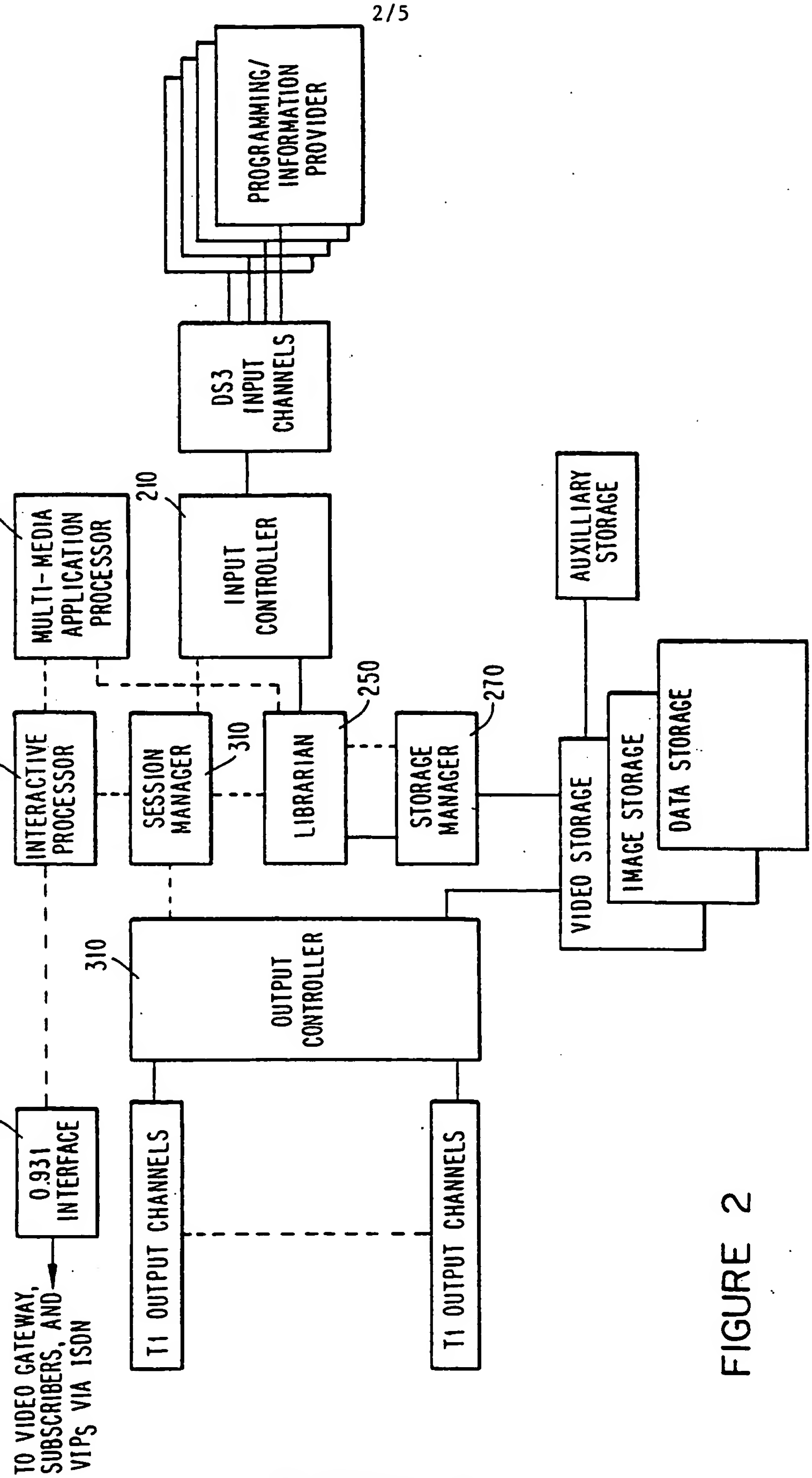

PROGRAMMING/ INFORMATION PROVIDER
DS3 INPUT CHANNELS
370
MULTI-MEDIA APPLICATION PROCESSOR
210
INPUT CONTROLLER
AUXILLIARY STORAGE
250
270
350
INTERACTIVE PROCESSOR
SESSION MANAGER
310
LIBRARIAN
STORAGE MANAGER
VIDEO STORAGE
IMAGE STORAGE
DATA STORAGE
310
OUTPUT CONTROLLER
230
0.931 INTERFACE
T1 OUTPUT CHANNELS
T1 OUTPUT CHANNELS
TO VIDEO GATEWAY, SUBSCRIBERS, AND VIPs VIA ISDN

FIGURE 2

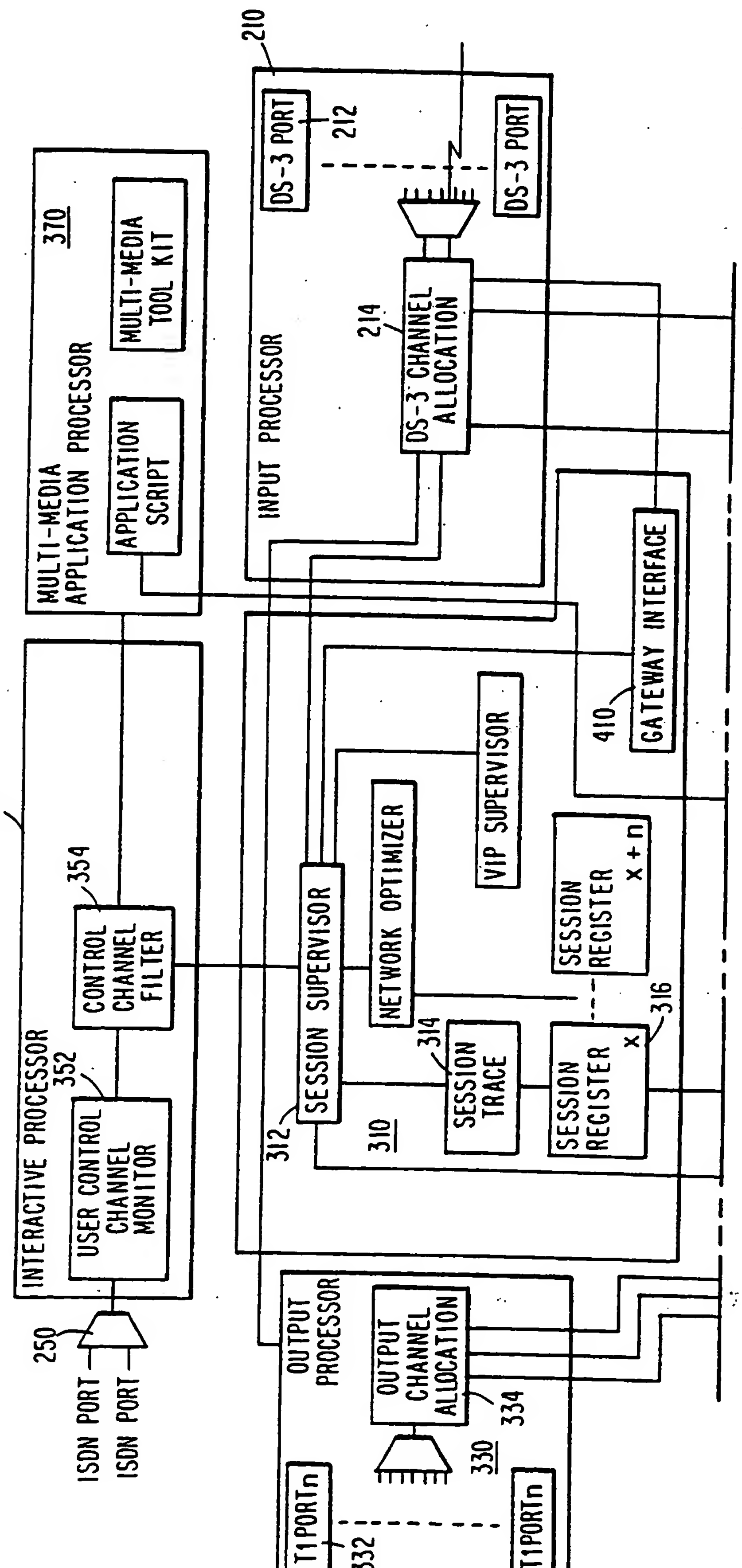



FIGURE 3A

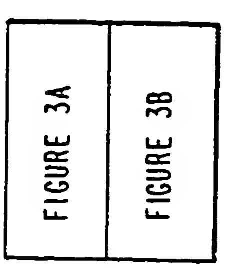
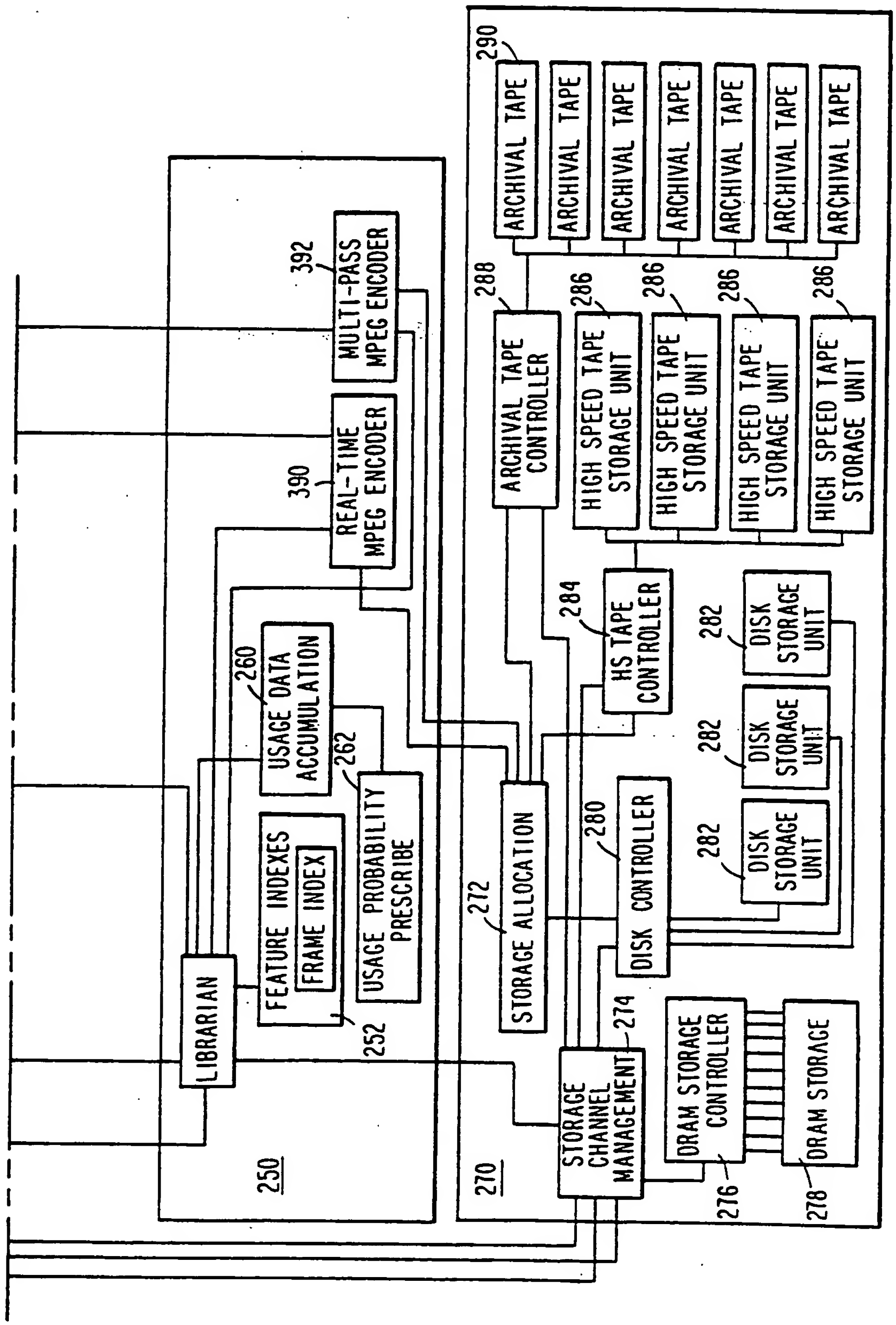



FIGURE 3


250
LIBRARIAN
FEATURE INDEXES
FRAME INDEX
252
USAGE PROBABILITY PRESCRIBE
262
USAGE DATA ACCUMULATION
260
REAL-TIME MPEG ENCODER
390
MULTI-PASS MPEG ENCODER
392
270
STORAGE CHANNEL MANAGEMENT
274
STORAGE ALLOCATION
272
DRAM STORAGE CONTROLLER
276
DRAM STORAGE
278
DISK CONTROLLER
280
DISK STORAGE UNIT
282
DISK STORAGE UNIT
282
DISK STORAGE UNIT
282
HS TAPE CONTROLLER
284
HIGH SPEED TAPE STORAGE UNIT
286
HIGH SPEED TAPE STORAGE UNIT
286
HIGH SPEED TAPE STORAGE UNIT
286
HIGH SPEED TAPE STORAGE UNIT
286
ARCHIVAL TAPE CONTROLLER
288
ARCHIVAL TAPE
290
ARCHIVAL TAPE
ARCHIVAL TAPE
ARCHIVAL TAPE
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ARCHIVAL TAPE
ARCHIVAL TAPE

FIGURE 3B

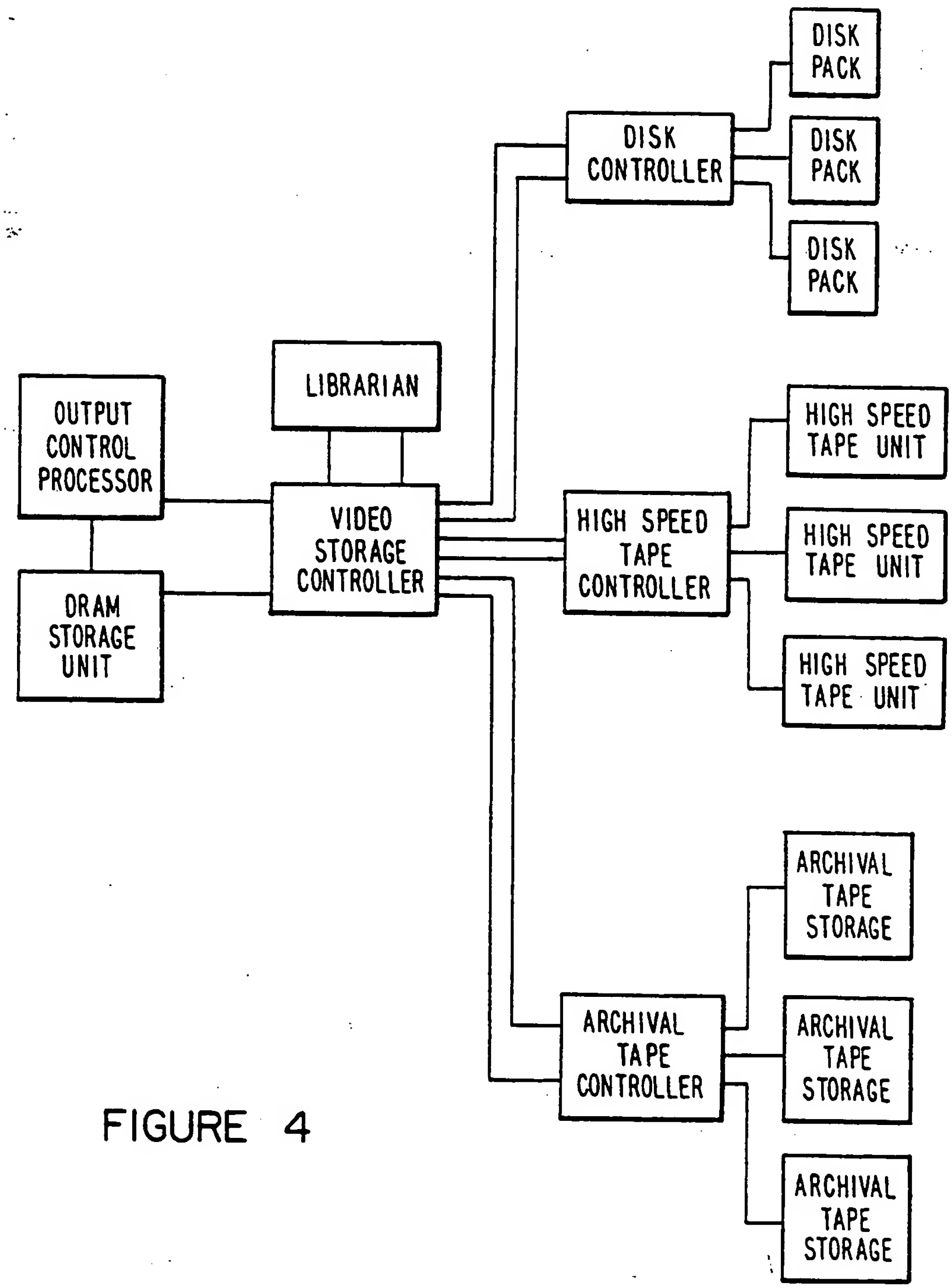
DISK PACK
DISK PACK
DISK PACK
DISK CONTROLLER
LIBRARIAN
OUTPUT CONTROL PROCESSOR
VIDEO STORAGE CONTROLLER
DRAM STORAGE UNIT
HIGH SPEED TAPE UNIT
HIGH SPEED TAPE UNIT
HIGH SPEED TAPE UNIT
HIGH SPEED TAPE CONTROLLER
ARCHIVAL TAPE STORAGE
ARCHIVAL TAPE STORAGE
ARCHIVAL TAPE STORAGE
ARCHIVAL TAPE CONTROLLER

FIGURE 4

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/05982

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC(5) :H04N 1/00, 7/00, 7/10, 7/14; H04M 11/00
US CL :358/84, 85, 86; 379/93, 96, 97, 98, 100
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 358/84, 85, 86; 379/93, 96, 97, 98, 100

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US, A, 5,027,400 (Baji et al) 25 June 1991, see the entire document. | 1-26 |
| A | US, A, 4,972,462 (Shibata) 20 November 1990, col. 5, line 60 through col. 9, line 51. | 1-8,13-17, 19, 20, 22-25 |
| A | US, A, 4,518,989 (Yabiki et al) 21 May 1985, col. 2, line 5 via col. 5 line 22. | 1, 2, 4-8, 13, 19, 22-26 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be part of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 AUGUST 1993 | 01 SEP 1993 |

| Name and mailing address of the ISA/US | Authorized officer |
|---|---|
| Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231 | JIN F. NG |
| Facsimile No. NOT APPLICABLE | Telephone No. (703) 305-4700 |

Form PCT/ISA/210 (second sheet)(July 1992)*

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# (54) System and method for indexing between trick play and normal play video streams in a video delivery system

(57) A system and method for indexing between video streams in an interactive video delivery system. The interactive video delivery system includes at least one media server which stores video streams having different presentation rates. In one embodiment the system stores a normal play stream and one or more corresponding trick play streams. The trick play video streams are fast forward and/or fast reverse video streams. The system generates index tables or look-up tables between the normal play and trick play video streams which enable indexing between the streams, and uses these look-up tables to switch back and forth between the streams. In creating the index tables, the system first analyzes the normal play stream and creates a normal play time standard based on presentation timestamps from the normal play stream. The system then creates an index table or look-up table for each of the normal play and trick play video streams using the normal play time standard. Each index table includes an array of two-tuples, wherein the two-tuples are the normal play time standard and an index or offset into the respective stream. The index tables enable indexing between the streams. During video delivery, the system uses the respective index tables to switch back and forth between the normal play and trick play video streams.

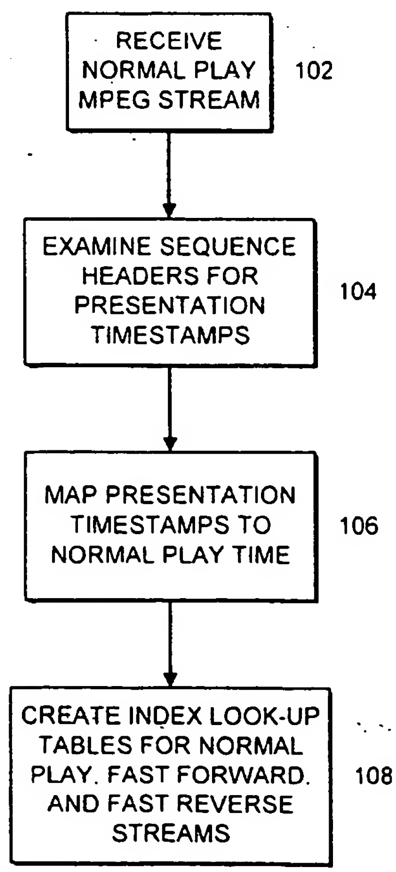


FIG. 4

EP 0 812 112 A2

Printed by Jouve, 75001 PARIS (FR)

D scription

## BACKGROUND OF THE INVENTION

### Fi ld of th Inv ntion

The present invention relates generally to video delivery and video-on-demand systems. and more particularly to a video server system and method for indexing between video streams having different presentation rates. i.e., normal play, fast forward and fast reverse video streams.

### Description of the Related Art

Video-on-demand or video delivery systems enable a plurality of users or viewers to selectively watch movies or other audio/video sequences which are stored on one or more video servers or media servers. The video servers are connected through data transfer channels, such as a broadcast cable system or satellite broadcast system, to the plurality of users or subscribers. The video servers store a plurality of movies or other audio/video sequences, and each user can select one or more movies from the video servers for viewing. Each user includes a television or other viewing device, as well as associated decoding logic, for selecting and viewing desired movies. When a user selects a movie; the selected movie is transferred on one of the data transfer channels to the television of the respective user.

Full-motion digital video requires a large amount of storage and data transfer bandwidth. Thus, video-on-demand systems use various types of video compression algorithms to reduce the amount of necessary storage and data transfer bandwidth. In general, different video compression methods exist for still graphic images and for full-motion video. Video compression methods for still graphic images or single video frames are referred to as intraframe compression methods, and compression methods for motion video are referred to as interframe compression methods.

Examples of video data compression for still graphic images are RLE (Run-Length-Encoding) and JPEG (Joint Photographic Experts Group) compression. The RLE compression method operates by testing for duplicated pixels in a single line of the bit map and storing the number of consecutive duplicate pixels rather than the data for the pixel itself. JPEG compression is a group of related standards that provide either lossless (no image quality degradation) or lossy (imperceptible to severe degradation) compression types. Although JPEG compression was originally designed for the compression of still images rather than video, JPEG compression is used in some motion video applications.

In contrast to compression algorithms for still images, most video compression algorithms are designed to compress full motion video. Video compression algorithms for motion video use a concept referred to as interframe compression, which involves storing only the differences between successive frames in the data file. Interframe compression stores the entire image of a key frame or reference frame, generally in a moderately compressed format. Successive frames are compared with the key frame, and only the differences between the key frame and the successive frames are stored. Periodically, such as when new scenes are displayed, new key frames are stored, and subsequent comparisons begin from this new reference point. It is noted that the interframe compression ratio may be kept constant while varying the video quality. Alternatively, interframe compression ratios may be content-dependent, *i.e.*, if the video clip being compressed includes many abrupt scene transitions from one image to another, the compression is less efficient. Examples of video compression which use an interframe compression technique are MPEG, DVI and Indeo, among others.

### MPEG Background

A compression standard referred to as MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and decompression of full motion video images which uses the interframe compression technique described above. MPEG compression uses both motion compensation and discrete cosine transform (DCT) processes and can yield compression ratios of more than 200:1.

A general background to and more information about MPEG can be found in the ISO/IEC MPEG specification referred to as ISO/IEC 13818, which is hereby incorporated by reference in its entirety.

The MPEG standard requires that sound be recorded simultaneously with the video data, and the video and audio data are interleaved in a single file to attempt to maintain the video and audio synchronized during playback. The audio data is typically compressed as well, and the MPEG standard specifies an audio compression method such as MPEG Layer II, also known by the Philips trade name of "MUSICAM".

An MPEG stream includes three types of pictures, referred to as the Intra (I) frame, the Predicted (P) frame, and the Bi-directional Interpolated (B) frame. The I or Intra frames contain the video data for the entire frame of video and are typically placed every 10 to 15 fram s. Intra frames provide entry points into the file for random access, and are generally only moderately compressed. Predicted fram s are encoded with reference to a past frame, i.e., a prior Intra

frame or Predicted frame. Thus P frames only include changes relativ to prior I or P frames. In general, Predicted frames receive a fairly high amount of compression and are used as references for futur Predicted frames. Thus, both I and P frames are used as references for subsequent frames. Bi-directional pictures include the greatest amount of compression and require both a past and a future reference in order to b encoded. Bi-dir ctional frames are not used for references for other fram s.

After the I frames have been created, the MPEG encoder divides each I frame into a grid of a suitable size, e.g., 16 x 16 pixel-squares, called macro blocks. The respective I frame is divided into macro blocks in order to perform motion compensation. Each of the subsequent pictures after the I frame are also divided into these same macro blocks. The encoder then searches for an exact, or near exact, match between the reference picture macro block and those in succeeding pictures. When a match is found, the encoder transmits a vector movement code or motion vector. The vector movement code or motion vector only includes information on the difference between the reference frame and the respective succeeding picture. The blocks in succeeding pictures that have no change relative to the block in the reference picture or frame are ignored. In general, for the frame(s) following a reference frame, i.e., P and B frames that follow a reference I or P frame, only small portions of these frames are different from the corresponding portions of the respective reference frame. Thus, for these frames, only the differences are captured, compressed and stored. Thus the amount of data that is actually stored for these frames is significantly reduced.

After motion vectors have been generated, the encoder then tracks the changes using spatial redundancy. Thus, after finding the changes in location of the macro blocks, the MPEG algorithm further reduces the data by describing the difference between corresponding macro blocks. This is accomplished through a math process referred to as the discrete cosine transform or DCT. This process divides the macro block into a suitable number of sub blocks, e.g., four sub blocks, seeking out changes in color and brightness. Human perception is more sensitive to brightness changes than color changes. Thus the MPEG algorithm devotes more effort to reducing color space rather than brightness.

Each picture or frame also includes a picture header which identifies the frame and includes information for that frame. The MPEG standard also includes sequence headers which identify the start of a video sequence. Sequence headers are only required once before the beginning of a video sequence. However, the MPEG-2 standard allows a sequence header to be transferred before any I frame or P frame. The sequence header includes information relevant to the video sequence, including the frame rate and picture size, among other information.

MPEG video streams used in digital television applications generally include a sequence header before every I frame and P frame. This is necessary to facilitate channel surfing between different video channels, which is an important user requirement. In general, when a user switches to a new channel, the video for the new channel cannot be displayed until the next sequence header appears in the stream. This is because the sequence header includes important information about the video sequence which is required by the decoder before the sequence can be displayed. If a sequence header were not included before each I frame and/or P frame, then when the user switched to a new channel, the video for the new channel possibly could not be immediately displayed, i.e., the video could not be displayed until the next sequence header.

The sequence headers in an MPEG encoded stream include presentation timestamps or a time base within the encoded stream. Timestamps provide a user with a time reference relative to the beginning of a movie, enabling the user to accurately select or identify a sequence located midstream of the movie without having to reference the beginning of the movie.

## Trick Play Streams

In an interactive video-on-demand (VOD) or near-video-on-demand (NVOD) system, it is greatly desirable for the user to be able to selectively fast forward and/or fast reverse through the movie being watched. Thus, some video-on-demand systems include fast forward and fast reverse streams, referred to as trick play streams, for each movie. When the user desires to fast forward or fast reverse through a movie, the user selects the fast forward or fast reverse option. The respective fast forward or fast reverse trick play stream is then transferred to the user at the appropriate point where the user was watching, instead of the normal play stream, thus simulating a fast forward or fast reverse of the movie being watched. Typically, a single video stream, such as a movie, is encoded at different presentation rates to enable the video file to operate in fast forward or fast reverse speed in addition to the normal play presentation rate.

## Indexing

Interactive video-on-demand syst ms which include trick play streams require methods for indexing between the normal play stream and the trick play streams, as well as for indexing between the trick play streams. In other words, when a user is watching a movie and choos s to fast forward for a period of time, a mechanism is needed for the video server to switch from the normal play str am to the appropriate point or fram in the fast forward stream. When the user then desires to resume watching at normal play speed, a mechanism is also needed for the video s rver to switch

from the frame b ing viewed in th fast forward stream to the appropriate point or fram in the normal play stream. Thus the video serv r must be able to determine the prop r positions within vid o files wh n a switch occurs in outputting a first video file at a first pr sentation rate to a second video fil at a second pr s ntation rate.

On approach for ind xing between normal play and trick play streams includ s using look-up tables to index b tween the various streams. The look-up tables each include a plurality of indices which reference respective positions or I frames in the various streams. For xampl , index look-up tabl s can be generated using the MPEG presentation timestamps from the sequence headers of the normal play stream.

One drawback to this approach is that the MPEG presentation timestamps may not always be available. For example, there is no requirement that the MPEG presentation timestamps be continuous, e.g., there could be breaks or gaps in the presentation timestamps.

Another problem is that presentation timestamps are presentation-based. Thus, when a fast forward stream which is 5x fast is being played, the presentation timestamps do not advance 5x faster, but advance at the same rate as they do in a normal play stream. Thus in this method the server is required to perform computations on the presentation timestamps to determine the corresponding place in another stream. This increases the real-time processing burdens on the media server.

This approach also requires each decoder to have intelligence, and further requires the media server to interact with the decoder to accomplish stream switches. For example, when the user selects the fast forward or fast reverse option, in this method the decoder is required to provide information back to the media server of the respective presentation timestamp where the decoder stopped playing, as well as the presentation rate of the stream being played. The media server then uses this information to determine the appropriate presentation timestamp location to begin playing in the new stream. This requirement that the decoder interact with the media server to accomplish stream switches, as well as the computations required to be performed by the media server, increases the overhead of the system. The interaction between the media server and the decoder also requires that each decoder have intelligence, which increases the cost of each decoder.

One such approach based on MPEG presentation timestamps is HP's "PictureNumber, PresentationTimeStamp, FileOffset" format for each table entry. Unfortunately, not all encoding formats are MPEG-based. Further, accurate mapping between presentation rates can be accomplished only if the underlying assumption that the presentation rate is a constant ratio, i.e. one assumes the encoded video stream has a uniform frame rate, is true. Conversely, a uniform frame rate at all presentation rates disables techniques such as "scene fast forward".

Therefore, an improved system and method is desired for efficiently indexing between normal play streams and trick play video streams in a video delivery system. An improved system and method is further desired which reduces the processing burdens of the media server.

## SUMMARY OF THE INVENTION

The present invention comprises a system and method for indexing between related video streams in an interactive video delivery system. The interactive video delivery system preferably comprises at least one media server which stores video streams having different presentation rates. In the preferred embodiment, the system stores a normal play stream and one or more corresponding trick play streams. The trick play video streams are fast forward and/or fast reverse video streams. The present invention generates index look-up tables (ILUTs) between the normal play and trick play video streams which enable indexing between the streams, and the present invention uses these ILUTs to switch back and forth between the streams.

In the preferred embodiment, the media server stores normal play video streams which are preferably compressed using any of various types of video compression methods, preferably an MPEG method. In creating the ILUTs, the system first analyzes the normal play stream and creates a normal play time standard based on presentation timestamps comprised in the normal play stream. The system then preferably creates an index look-up table for each of the normal play and trick play video streams using the normal play time standard. Each index table comprises an array of two-tuples, wherein the two-tuples are the normal play time standard and an index or offset into the respective stream. The index tables enable indexing between the streams.

During video delivery, the system of the present invention uses the respective index tables to switch back and forth between the normal play and trick play video streams. For example, when a user is viewing the normal play stream and desires to fast forward through the video stream, the media server examines the current normal play time and offset of the normal play stream being output in order to half the normal play stream at an appropriate point. The media server also uses the current normal play time to retrieve the appropriate offset in the fast forward stream index table. This offset is then used to b gin play of the fast forward stream at the appropriate point or frame when the normal play stream is halted. When the user discontinues fast forwarding and selects normal play, the media server examines the current normal play time and offset of the fast forward stream being output to halt the fast forward stream at an appropriat point. The m dia server also uses the current normal play time of the fast forward stream to retrieve the appro-

priate offset in the normal play stream index table. This offset is then used to begin play of the normal play str am at the location where the first forward stream was halted. Similar operations occur when the user fast reverses through the video stream. The pres nt inv ntion also provides a smooth transition between streams having different presentation rates by ensuring that stoppage and initiation of output of the different streams, i.e., switching the output between the different streams, only occurs at well defined "random access" points.

Therefore, the present invention fficiently allows indexing between normal play and trick play streams. The present invention creates a normal play time standard which is used as a common reference, thus simplifying the indexing process. This eliminates the requirement of any intelligence in the decoder and reduces the processing requirements of the video server.

## DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

**Figure 1** illustrates a video delivery system including one or more media servers and one or more subscribers;
**Figure 2** illustrates the media server of Figure 1;
**Figure 3** is a block diagram illustrating the media server computer system of Figure 2;
**Figure 4** is a flowchart diagram illustrating generation of index look-up tables for normal play and trick play streams according to the present invention;
**Figure 5** illustrates index look-up tables for normal play and trick play streams according to the present invention; and
**Figure 6** is a flowchart diagram illustrating operation of the media server indexing between a normal play and trick play streams according to the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

### Video Delivery System

Referring now to Figure 1, a video server or video delivery system 30 for storing and transferring video streams is shown. The system 30 is preferably a video-on-demand (VOD) or near-video-on-demand (NVOD) system, or other type of video delivery system, which is capable of transferring or playing video or multimedia streams to one or more users, preferably a plurality of users. In the present disclosure, the term "video stream" is used to refer to a file or sequence of data for presenting a video display. The term "video stream" also includes a multimedia stream which includes both video and audio components.

As shown, in one embodiment the video delivery system 30 comprises one or more media servers or video servers 50 connected through a broadband network 40 to a plurality of subscribers 52. As discussed below, each media server 50 preferably includes a general purpose computer system 60 (Fig. 2). The broadband network 40 is preferably a network suitable for multimedia content, such as an ATM (Asynchronous Transfer Mode) network. The subscribers 52 preferably include display devices such as televisions, computers, etc.

The media server 50 is capable of transferring or playing video or multimedia streams having different presentation rates. In the preferred embodiment, the system 50 is capable of transferring or playing either a normal play stream or one or more trick play streams. The trick play streams may comprise one or more of a fast forward and/or fast reverse stream. Thus, in the present disclosure, the term "trick play streams" refers to fast forward and/or fast reverse video streams, preferably compressed streams, which are generated from a normal play stream, and which have a different presentation rate than the normal play stream.

As noted above, the normal play and trick play streams are preferably compressed video streams. An embodiment of the invention operates independently of the type or format of the video streams. Thus the video streams may be compressed in any of various types of formats, including MPEG-1, MPEG-2, Motion JPEG, QuickTime, etc. Further, an embodiment of the invention operates independently of the frame rate and other presentation characteristics.

### Figure 2 - Media Server

Referring now to Figur 2, in this embodiment the media server or video server 50 comprises a computer system 60. Figure 3 is a block diagram illustrating the components comprised in the media server computer system 60 of Figure 2. The media server computer system 60 includes various standard components, including one or more processors, one or more bus s, a hard drive and memory. It is noted that Figure 3 is illustrativ only, and other computer architectures may be used, as desired. As shown, the computer system 60 includes at least one processor 80 coupled

through chips t logic 82 to a system memory 84. The chipset 82 includes a PCI (Peripheral Component Interconnect) bridge for interfacing to PCI bus 86. The computer system 60 includes a RAID (Redundant Array of Inexpensive Disks) disk array 90 or other storage media for storing the normal play streams and corresponding trick play streams. The computer system 60 may include ith r or both of an MPEG decoder 74 and MPEG encoder 76, which are shown connected to PCI bus 86. Th computer system 60 may also include video circuitry 88, as shown.

Referring again to Figur 2, th computer system 60 includes or is coupled to one or more digital storage or media storage devices. For example, in the embodiment of Figure 2 the computer system 60 couples to a media storage unit 62 through cable 64. The media storage unit 62 may be in addition to, or instead of, a disk storage system in the computer system 60. The media storage unit 62 includes one or more composite RAID drives for storing the normal play streams and corresponding trick play streams. Alternatively, the media storage unit 62 may instead include one or more CD-ROM drives and/or one or more Digital Video Disk (DVD) storage units, or other types of media, for storing digital video. The computer system 60 may also include one or more internal CD-ROM drives or may couple to one or more separate Digital Video Disk (DVD) storage units. The computer system 60 also may connect to other types of digital or analog storage devices, as desired.

The compressed normal play and trick play streams may be comprised on a storage media in the media server 50, such as a RAID disk array, CD-ROM or Digital Video Disk (DVD). The media server 50 reads the respective normal play or trick play stream from the storage media and provides the data out to the one or more display units or viewers (subscribers) 52. The media server 50 may output the video data using various communication media, such as ATM (Asynchronous Transfer Mode), ISDN (Integrated Services Digital Network), or via satellite. As noted above, the subscriber display units may comprise televisions, computer systems or other systems with a display screen for displaying video content.

As mentioned above, media server 50 indexes or switches between normal play and trick play video streams, generally based on user selections. As discussed further below, the media server 50 generates index tables for the various streams and uses these tables to switch between the various streams. In this embodiment, the index table generation and indexing functions are performed by the media server 50 in software, wherein the software is represented by floppy disks 72. In another embodiment, the computer system 60 includes dedicated hardware which performs one or both of the index table generation and indexing functions.

It is noted that the media server 50 may comprise two or more interconnected computers, as desired. It is noted that any of various types of video delivery systems may be used according to the present invention, as desired.

## Figure 4 --Creation of Index Look-up Tables

Referring now to Figure 4, a diagram illustrating generation of index look-up tables (LUTs) according to the present invention is shown. Here it is presumed that a normal play stream and one or more trick play streams are stored in the system. The different streams preferably encode the same content for presentation at different rates.

As shown in step 102, server 50 receives or examines a normal play video stream or multimedia stream. As discussed above, the normal play stream comprises a stream of video data which is used to present a video sequence, such as a television segment or movie, onto a screen, such as a television or a computer system. In this embodiment, the normal play stream is a compressed stream, preferably an MPEG-2 compressed stream, although other types of compression may be used, as desired. Accordingly, the index LUTs are generated using the existing MPEG-encoded video stream.

In step 104, server 50 analyzes timestamps within the stream. In this embodiment where the stream is an MPEG stream, the system analyzes the presentation timestamps from the sequence headers in the stream. As mentioned above, the presentation timestamps are used to provide a time base for the video sequence.

As discussed above, an MPEG encoded stream includes a plurality of I frames which are intracoded pictures, and a plurality of B and P frames which are intercoded frames. The I frames each contain video data for an entire frame of video and are placed periodically in the sequence. The P and B frames include change information relative to prior or subsequent frames. Each picture or frame also includes a picture header which identifies the frame and includes information for that frame. An MPEG encoded stream further includes one or more sequence headers which include certain information regarding the video sequence, including the frame rate and the picture size, among other information. The sequence headers include presentation timestamps which indicate the play time of the video sequence.

In step 106 server 50 maps the presentation timestamps to a "normal play time" (NPT) standard. Thus server 50 defines a multimedia index based on the concept of NPT that can be associated with a "position" within a multimedia title. Positions are defined to be equivalent between multimedia or video streams having different presentation rates when th content pr sent at the r spective position is conceptually substantially equivalent. Henc , for video data, the position is defined to be equivalent when the same or substantially the same image in the sequence is being presented, allowing for differences in resolution and other encoding parameters than may be particular to th stream.

In an embodim nt of the invention, NPT provides an indication of contextual position within a compressed video

stream, or any oth r multimedia fil , by assigning an increasing numeric valu to succeeding elements, e.g., frames or sequences, in the stream. As a result, NPT permits the location of a particular item of content within the video stream to be determined regardless of the presentation rate, encoding scheme or storage medium.

In generating the normal play time standard, server 50 examines the presentation timestamps and keeps track of the original or base pr sentation timestamp at the beginning of the movie. Server 50 then subtracts that base or original presentation timestamp from subsequent timestamps to determine the normal play time values for the normal play stream, thereby compensating for any non-zero base presentation timestamp. In other words, in order to calculate normal play time for a given point in the normal play stream, the system subtracts the base presentation timestamp from a future presentation timestamp at the respective point or location in the normal play stream to determine the normal play time value for that location.

In this embodiment, the normal play time (NPT) for a position in a multimedia stream is the time from the beginning of the title until the respective position when measured by presentation of the normal speed forward or normal play stream. Therefore, the concept of normal play time is used. Normal play time corresponds to the speed of the normal play stream and has a one to one correspondence with clock time. Thus, every second the normal play movie ticks forward, normal play time clicks forward one second. In a fast forward file or fast forward trick play stream, if the FF stream is 5x faster, normal play time is 5x faster as the user is watching.

In general, any particular scene in the movie is identified by a normal play time. Thus, if a particular scene occurs at X minutes into the movie in normal play time, then this position or scene is referred to as or called X minutes. This particular scene is also located in any of the other trick play streams at X minutes normal play time. Thus in the fast forward and fast reverse streams, even though time is going by much faster, at X minutes normal play time the particular scene occurs.

In step 108 server 50 creates an index look-up tables for each of the multimedia streams, i.e., for the normal play stream and each of the trick play streams. The index look-up table for the normal play multimedia stream comprises an index or array of two-tuples. The index look-up tables for a normal play, fast forward, and fast reverse stream are shown in Figure 5. As shown, each tuple comprises a normal play time value and a corresponding file offset within the stream.

Note that the entries in each NPT index may be constrained by requirements of the encoding scheme. For example, some encoding schemes may only allow random positioning into the encoded stream at certain non-linear intervals. In the case of an MPEG2 transport stream, the "random access indicator" is set within the transport packet header to indicate the file offsets of the respective encoded data packets and resulting NPT indices are "randomly accessible".

For the normal play stream, the normal play time entries comprise the normal play time values computed in step 106. For the scaled streams, e.g., the fast forward and fast reverse streams, a scale factor is introduced into the normal play time values of the index look-up tables to compensate for the different presentation rates. Scaling of the presentation timestamps can be accomplished by multiplying the compressed presentation timestamp value by the ratio of the presentation rate to the normal presentation rate.

It is noted that equivalent positions in multimedia streams having different presentation rates will have equal NPT values, although the actual time presentation from the beginning of the stream to that position will differ for the different streams. It is also noted that equivalent positions in multimedia streams having different presentation rates, although having equal NPT values, will have different byte offsets due to a presumptive difference in length of the streams having different presentation rates.

The index look-up tables specify indices or entries each based on a normal play time and a file offset to allow the multimedia server 50 to initiate or stop play at a particular normal play time point in the multimedia stream. The index look-up table indices also allow the multimedia server 50 to transfer to and between equivalent positions between streams of different presentation rate, i.e., between normal play and trick play streams. The index look-up table only includes tuples representing valid positions for starting stopping, or transferring between the streams.

The creation of the look-up tables is independent of any particular type of video compression or MPEG representation. Hence, where MPEG compression is used the index look-up tables are created by scanning through the MPEG file, noting random access points in the MPEG file to compensate for presentation timestamp discontinuities, and then converting from the presentation timestamp in the MPEG file into the normal play time standard. Conceptually, each index table comprises an array of normal play time vs. scenes, and any particular image in the movie can be identified by the normal play time value. As noted above, an index table is created for each presentation rate, e.g., fast forward, fast reverse, and normal play. Each of the offsets stored in the index table is an index from the normal play time to a byte offset in that MPEG file where the particular scene begins.

Hence, server 50 us s a normal play time standard, inst ad of using timestamps in the video stream. As noted above, the presentation timestamps in an MPEG sequence are typically not always available. For exampl , there is no requirement that the timestamps be continuous, e.g., there could be breaks or gaps in the presentation timestamps. Therefore, unlike prior art methods, an embodiment of the invention do s not use the presentation timestamps as a basis for creating the ind x tabl s. Instead, an embodiment of the invention maps the presentation timestamps to a

normal play tim standard, and this normal play time standard is then used as a basis for creating the index tables.

**Figur 6 - Transferring Between Str ams**

Referring now to Figur 6, a flowchart diagram illustrating operation of the system of the present invention transferring outputs between multimedia str ams having different presentation rates is shown. Here it is assumed that a current video or multimedia stream is being output from the media server 50, and the media server 50 has received user input indicating that a different stream should be output. For example, the media server may be providing the normal play multimedia stream, and the media server 50 receives user input of a fast forward or fast reverse selection, indicating that either the fast forward or fast reverse trick play stream should be output at the appropriate point.

When user input is received indicating a desired change in the presentation rate, then in step 202 the media server 50 finds a tuple in the index table of the current stream or file that contains an offset beyond the current output offset. In other words, assuming that the current stream is playing and is at a certain point or offset within the stream, in step 202 the media server 50 finds the tuple or entry in the index table of the current stream that contains an offset that is at or just beyond the current output offset. The current output offset is preferably provided by media file system (MFS) software executing in the media server 50. In step 202 the media server 50 receives this byte offset of the current output of the stream and searches the index table for the nearest offset greater than or equal to the byte offset of the current output of the stream.

In step 204 the media server 50 schedules the current stream to terminate output at this offset determined in step 202. Thus, in order to terminate a current stream being output, the media server 50 preferably finds the tuple for the nearest subsequent normal play time or nearest offset of the location currently being played and utilizes the associated offset of this type to terminate play of the current video stream at this offset.

In step 206 the media server 50 determines the normal play time for the current stream. It is noted that the normal play time for the current stream may have been previously determined in step 202. In other words, having determined the nearest offset greater than the byte offset of the current output stream in step 202, the corresponding normal play time value in this tuple may be used as the normal play time for the current stream.

In step 208 media server 50 finds the tuple in the index table of the new stream, i.e., the stream to be output with the nearest normal play time to the normal play time of the current stream. In step 210 the media server 50 uses the offset of the found tuple in step 208 to initiate output of the new stream at that offset. The output of the new stream is preferably initiated after the current stream terminates, wherein the current stream is scheduled to terminate in step 204 as described above.

Therefore, initiation and termination of the output of a respective stream being output at a given normal play time is accomplished by finding the tuple in the respective index table for the nearest normal play time and utilizing the associated file offset as the point to initiate or terminate play of the stream. Transferring between different multimedia data streams having different presentation rates is accomplished by utilizing entries in each of the respective tables of the current stream and the new stream to be played to reschedule termination of output of the current stream and the beginning of play of the new stream.

In sum, the present invention provides a system and method for indexing between normal play and trick play video streams. An embodiment of the invention examines the presentation timestamps in the sequence headers of the normal play stream and creates a normal play time standard which is used for all streams. The system then creates index tables or look-up tables for the stream. The index tables for the streams comprise normal play time values and corresponding offsets into the respective stream. During play, the video delivery system uses these index tables to intelligently jump or index between the normal play and trick play streams. This approach also permits non-constant presentation rates such as scene forward or presentation rates based on content complexity.

Other modifications may be used to generate a normal play time standard for the normal play stream without departing from the present invention. For example, NPT index LUTs can also be generated prior to encoding of the video streams by using frame numbers or sequence numbers. Alternatively, the NPT indices may be generated concurrently with the video content encoding. In either case, NPT indices can be generated by multiplying the frame number by the frame rate. This NPT position can then be associated with the file offset of the encoded frame.

In yet another exemplary embodiment, the video content is encoded at a constant bit rate. Accordingly, NPT entries for some (possibly proper) subset of the random access point specified by the encoded video stream may be generated using the following equations:

For forward presentations (i.e. positive presentation rate scale factor), the NPT value for each file offset at which a Random Access Point occurs may be calculated using the equation:

$$NPT = (PresentationRateScaleFactor * FileBitOffset) / ConstantBitRate$$

Conversely, for revers presentations (i.e. negativ presentation rate scal factor), the NPT value for each file offset may be calculated using the quation:

$$NPT = TotalNPT + ((PresentationRateScaleFactor * FileBitOffset) / ConstantBitRate)$$

Wherein:

PresentationRateScaleFactor = ratio of presentation rate with respect to normal presentation rate (e.g. a value of 7 indicates 7x fast forward, a value of -5 indicates 5x fast reverse);
FileBitOffset = the number of bits from the beginning of the encoding to the file offset specified as a random access point;
ConstantBitRate = the constant bit rate at which the encoding is intended to be played; and
TotalNPT = the total time duration of normal speed presentation (i.e. what would be commonly though of as the length of the movie).

Although the system and method of the present invention has been described in connection with the described embodiments, it is not intended to be limited to the specific form set forth herein, but on the contrary, it is intended to cover such alternatives, modifications, and equivalents, as can be reasonably included within the scope of the invention.

## Claims

1. A computer-implemented method for indexing a first and a second related video stream having different presentation rates, the method comprising the step of creating index look-up tables (LUTs) for each of said related video streams using a normal play time standard, wherein each of said index LUTs includes a plurality of entries comprising a normal play time value and a corresponding offset into the respective video stream.

2. The method of claim 1, wherein the video streams include a normal play stream, wherein said creating index look-up tables for said first and second video streams includes:

   receiving the normal play stream, wherein the normal play stream includes a plurality of timestamps; and
   mapping said plurality of timestamps to said normal play time standard;

   wherein said creating index look-up tables for said first and second video streams uses said normal play time standard.

3. The method of claim 2, wherein said video streams having different presentation rates comprise MPEG compressed streams;
   wherein said mapping said plurality of timestamps to a normal play time standard comprises examining sequence headers in said MPEG compressed normal play stream for said plurality of timestamps.

4. The method of claim 1, wherein said video streams-include trickplay streams including a fast forward stream and a fast reverse stream.

5. The method of claim 1, wherein said normal play time has a one to one correspondence to clock time.

6. A computer-implemented method for transitioning between a first and a second related video stream having different presentation rates, the method comprising:

   creating index look-up tables (LUTs) for each of said related video streams using a normal play time standard, wherein each of said index LUTs includes a plurality of entries comprising a normal play time value and a corresponding offset into the respective stream;
   transferring video data from said first video stream; and
   switching between said first video str am and said second video stream using said index look-up tables.

7. The method of claim 6, wher in the video streams include a normal play stream, wherein said creating index look-up tables for said first and second video streams includes:

receiving the normal play stream, wherein the normal play stream includes a plurality of timestamps: and
mapping said plurality of timestamps to said normal play time standard:

wherein said creating index look-up tables for said first and second video streams uses said normal play time standard.

8. The method of claim 7, wherein said video streams comprise MPEG compressed streams;
wherein said mapping said plurality of timestamps to a normal play time standard comprises examining sequence headers in said MPEG compressed normal play stream for said plurality of timestamps.

9. The method of claim 6, wherein said switching between said first and second streams includes:

determining the normal play time of said first video stream;
determining an offset in the second video stream based on the normal play time of the first video stream; and
initiating output of the second video stream at said determined offset in the second video stream.

10. The method of claim 9, wherein said determining an offset in the second video stream based on the normal play time of the first video stream comprises:

finding an entry in an index look-up table of said second video stream having a normal play time value close to the normal play time of the first video stream; and
determining the offset in said found entry in said index look-up table of said second video stream.

11. The method of claim 9, wherein said switching between said first and second video streams further comprises:

determining an entry in an index table for the first video stream that contains an offset beyond an offset of data currently being output from the second video stream; and
scheduling output of the current stream to terminate at said offset beyond the offset of data currently being output from the first video stream.

12. The method of claim 6, wherein the video streams having different presentation rates include trickplay streams including a fast forward stream and a fast reverse stream.

13. The method of claim 6, wherein said normal play time has a one to one correspondence to clock time.

14. A computer-implemented method for transitioning between a first and a second related video stream, each said video stream having different presentation rates, the method comprising:

transferring video data from said first video stream;
referencing an index look-up table (LUT) for each said video stream, wherein each said LUT includes a plurality of entries comprising a normal play time (NPT) value and a corresponding offset into the respective video stream;
switching from said first video stream to said second stream using the index LUTs; and
transferring video data from said second video stream.

15. The method of claim 14, wherein the video streams include a normal play stream, wherein said creating index look-up tables for said first and second video streams includes:

receiving the normal play stream, wherein the normal play stream includes a plurality of timestamps; and
mapping said plurality of timestamps to said normal play time standard;

wherein said creating index look-up tables for said first and second video streams uses said normal play time standard.

16. The method of claim 15, wherein said video streams comprise MPEG compressed streams;
wherein said mapping said plurality of timestamps to a normal play time standard comprises examining sequence headers in said MPEG compressed normal play stream for said plurality of timestamps.

17. The method of claim 14, wherein said switching between said first and second streams includes:

determining the normal play time of said first video stream;
determining an offset in the second video stream based on the normal play time of the first video stream; and
initiating output of the second video stream at said determined offset in the second video stream.

18. The method of claim 17, wherein said determining an offset in the second video stream based on the normal play time of the first video stream comprises:

finding an entry in an index look-up table of said second video stream having a normal play time value close to the normal play time of the first video stream; and
determining the offset in said found entry in said index look-up table of said second video stream.

19. The method of claim 17, wherein said switching between said first and second video streams further comprises:

determining an entry in an index table for the first video stream that contains an offset beyond an offset of data currently being output from the second video stream; and
scheduling output of the current stream to terminate at said offset beyond the offset of data currently being output from the first video stream.

20. The method of claim 14, wherein the video streams having different presentation rates include trickplay streams including a fast forward stream and a fast reverse stream.

21. The method of claim 14, wherein said normal play time has a one to one correspondence to clock time.

22. A video server which provides video streams having different presentation rates, wherein the video server indexes between said video streams having different presentation rates, the video server comprising:

video memory configured to store the video streams having different presentation rates;
an index look-up table (LUT) for each of said video streams, wherein the index look-up tables are based on a normal play time standard, wherein each of said index look-up tables includes a plurality of entries comprising a normal play time value and a corresponding offset into the respective stream;
one or more output ports coupled to said video memory for transferring video data from a video stream; and
a switch coupled to said video memory and said memory, and configured to switch between said video streams at said one or more output ports, wherein said switch uses said index look-up tables in switching between said video streams.

23. The video server of claim 22,wherein the video streams include a normal play stream, the video server further configured to create indices for said LUTs by examining the normal play stream which includes a plurality of timestamps and by mapping said plurality of timestamps to said normal play time standard.

24. The video server of claim 22, wherein said video streams includes MPEG compressed streams, and said LUT generator maps said plurality of timestamps to said normal play time standard by examining sequence headers in said MPEG compressed normal play stream for said plurality of timestamps.

25. The video server of claim 22,further configured to determine the normal play time of a current stream being played, to determine an offset in a new stream based on the normal play time of the current stream, and to initiate output of the new stream at said determined offset in the new stream.

26. The video server of claim 25, further configured to locate an entry in an index look-up table of said new stream having a normal play time value close to the normal play time of the current stream, and to determine the offset in said found entry in said index look-up table of said new stream.

27. The video server of claim 25, further configured to determine an entry in an index table for the current stream that contains an offset beyond an offset of data currently being output from the current stream and to schedule output of the current stream to terminat at said offset beyond the offset of data currently being output from the current stream.

28. The video server of claim 22, wherein th video streams having different presentation rates include trickplay streams including a fast forward stream and a fast r verse stream.

29. The video server of claim 22, wherein said normal play time has a one to one correspondence to clock time.

30. A computer-readable storage media for operating in a computer system, the computer system including a central processing unit and memory, wherein the computer system stores video streams having different presentation rates, wherein the computer-readable storage media includes a substrate having a physical configuration repr - senting data, the storage media comprising:

an index look-up table creation program configured to create index look-up tables for each of said video streams using a normal play time standard, wherein each of said index look-up tables includes a plurality of entries comprising a normal play time value and a corresponding offset into the respective stream;
a video stream switching program configured to switch between output of a current stream and a new stream using said index look-up tables.

31. The computer-readable storage media of claim 30, wherein the video streams include a normal play stream, wherein said index look-up table creation program includes:

an examining program configured to examine the normal play stream, wherein the normal play stream includes a plurality of timestamps; and
a mapping program configured to map said plurality of timestamps to said normal play time standard;

wherein said index look-up table creation program uses said normal play time standard.

32. The computer-readable storage media of claim 30, wherein said video stream switching program includes:

a program configured to determine the normal play time of the current stream;
a program configured to determine an offset in the new stream based on the normal play time of the current stream; and
a program configured to initiate output of the new stream at said determined offset in the new stream.

33. The computer-readable storage media of claim 32, wherein said program for determining an offset in the new stream based on the normal play time of the current stream comprises:

a program configured to find an entry in an index look-up table of said new stream having a normal play time value close to the normal play time of the current stream; and
a program configured to determine the offset in said found entry in said index look-up table of said new stream.

34. The computer-readable storage media of claim 32, wherein said video stream switching program further comprises:

a program configured to determine an entry in an index table for the current stream that contains an offset beyond an offset of data currently being output from the current stream; and
a program configured to schedule output of the current stream to terminate at said offset beyond the offset of data currently being output from the current stream.

35. A video subscription system for receiving and displaying video streams having different presentation rates from a video server, wherein the video server indexes between said video streams having different presentation rates, the video subscription system comprising:

a video display device configured to display the video streams having the different presentation rates; and
a controller coupled to said video display device and configured to cause said video server to switch between said video streams by using an index look-up table (LUT) for each of said video streams, wherein the index look-up tables are based on a normal play time standard, wherein each of said index look-up tables includes a plurality of entries comprising a normal play time (NPT) value and a corresponding offset into the respective stream, and wherein said video streams include a normal play stream and said entries are created by examining the normal play stream which includ s a plurality of timestamps and by mapping said plurality of timestamps to said normal play time standard.

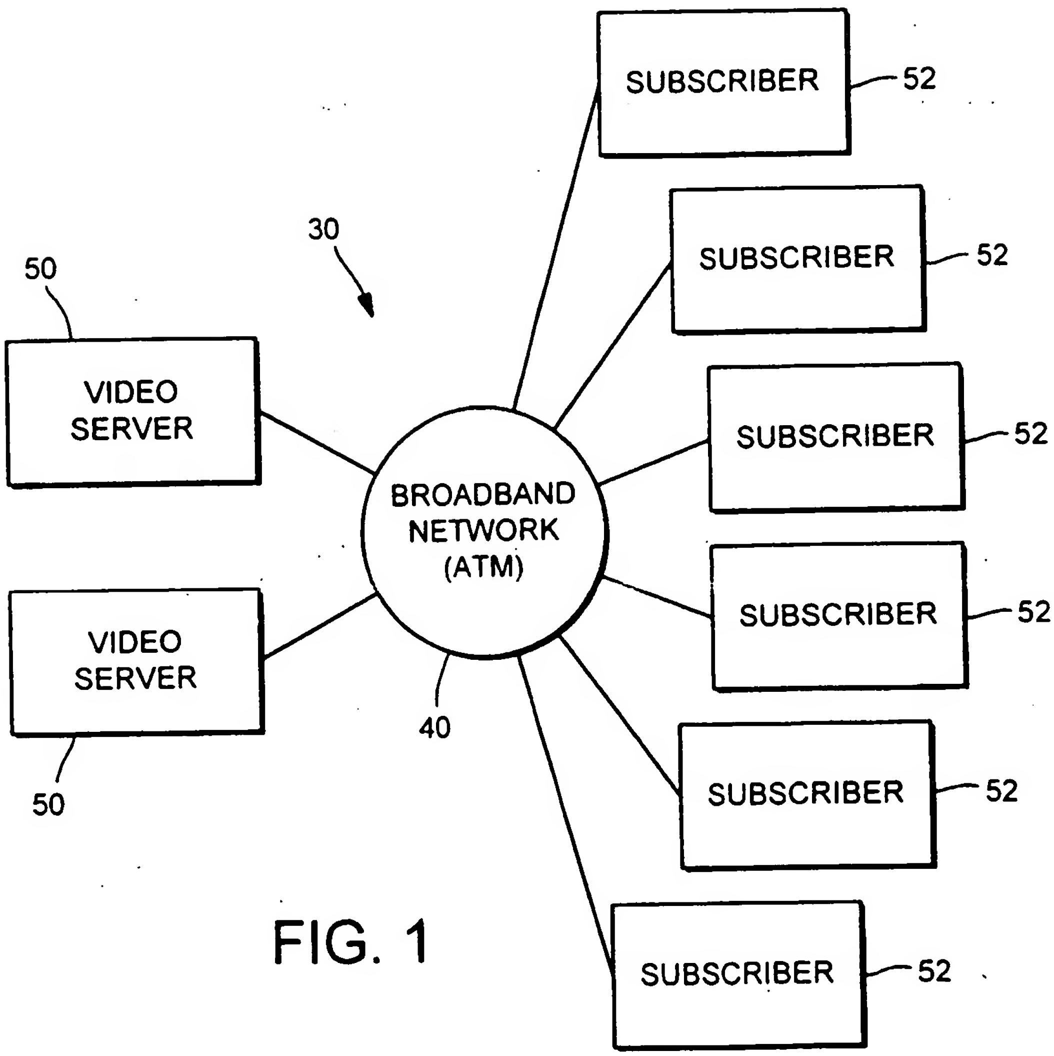
VIDEO SERVER
VIDEO SERVER
BROADBAND NETWORK (ATM)
SUBSCRIBER
SUBSCRIBER
SUBSCRIBER
SUBSCRIBER
SUBSCRIBER
SUBSCRIBER
30
40
50
50
52
52
52
52
52
52

FIG. 1

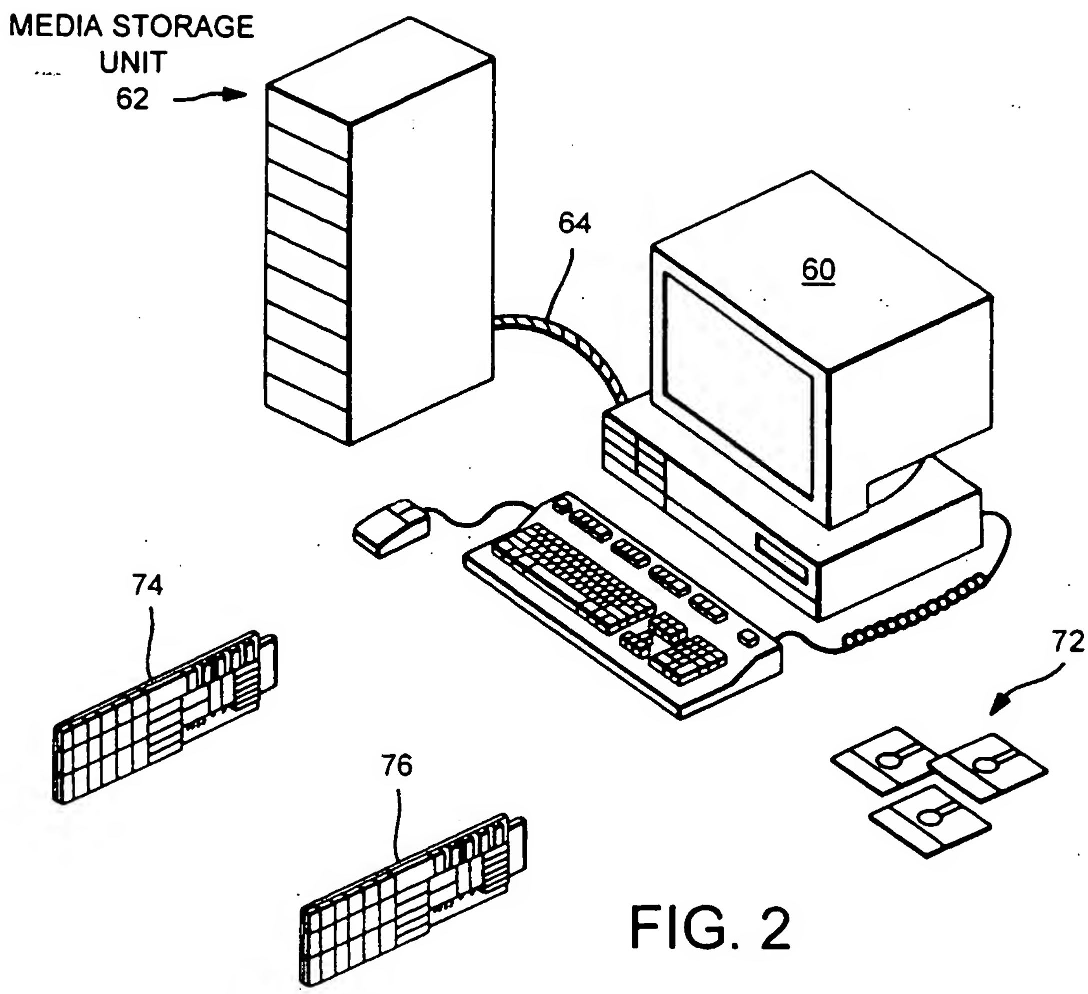


FIG. 2

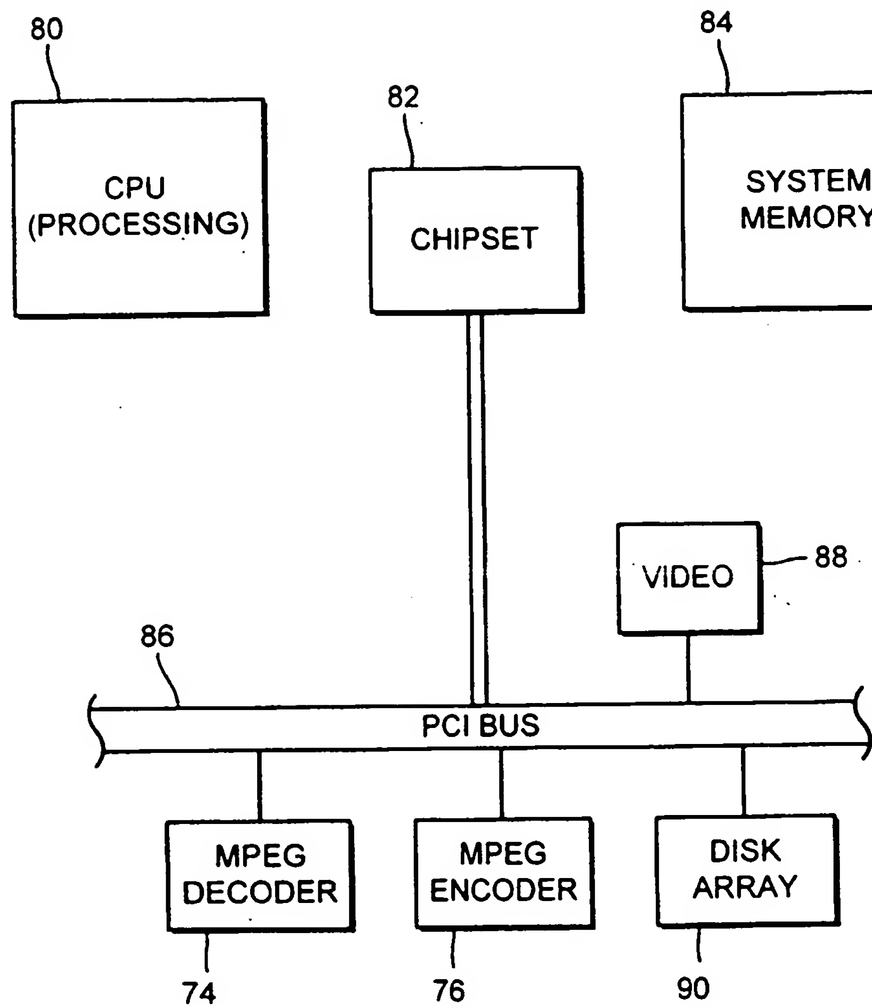
80
CPU (PROCESSING)
82
CHIPSET
84
SYSTEM MEMORY
VIDEO
88
86
PCI BUS
MPEG DECODER
MPEG ENCODER
DISK ARRAY
74
76
90

FIG. 3

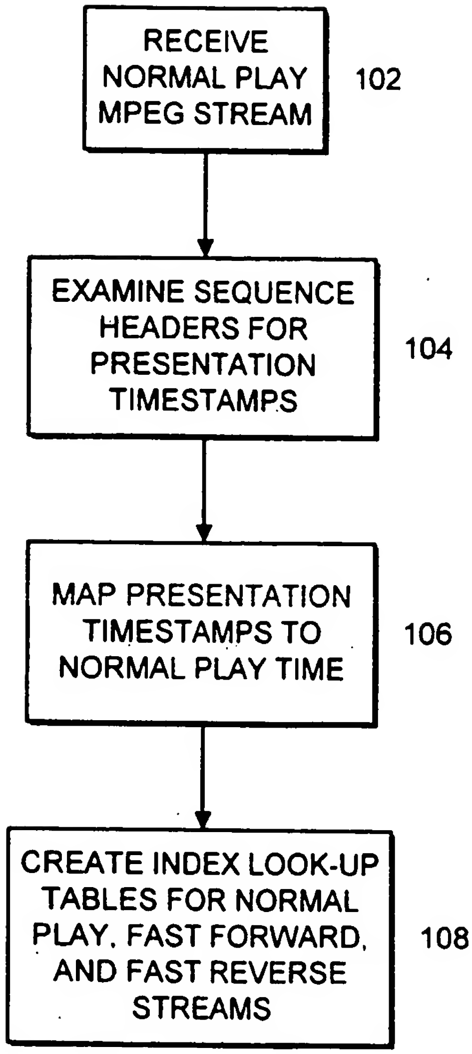
RECEIVE NORMAL PLAY MPEG STREAM
102
EXAMINE SEQUENCE HEADERS FOR PRESENTATION TIMESTAMPS
104
MAP PRESENTATION TIMESTAMPS TO NORMAL PLAY TIME
106
CREATE INDEX LOOK-UP TABLES FOR NORMAL PLAY, FAST FORWARD, AND FAST REVERSE STREAMS
108

FIG. 4

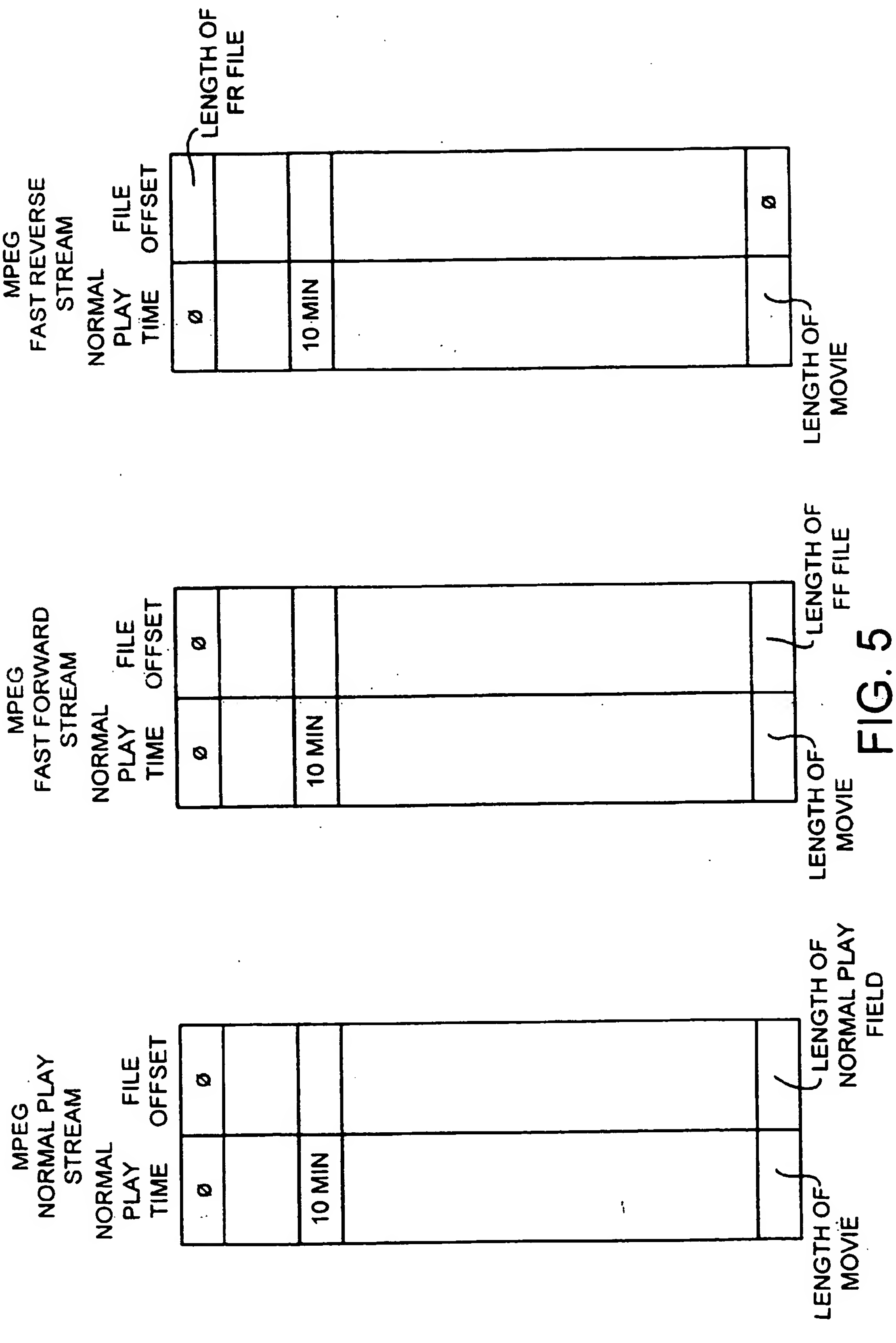
MPEG
NORMAL PLAY
STREAM
NORMAL
PLAY
TIME
FILE
OFFSET
Ø
Ø
10 MIN
LENGTH OF
MOVIE
LENGTH OF
NORMAL PLAY
FIELD
MPEG
FAST FORWARD
STREAM
NORMAL
PLAY
TIME
FILE
OFFSET
Ø
Ø
10 MIN
LENGTH OF
MOVIE
LENGTH OF
FF FILE
MPEG
FAST REVERSE
STREAM
NORMAL
PLAY
TIME
FILE
OFFSET
Ø
10 MIN
Ø
LENGTH OF
FR FILE
LENGTH OF
MOVIE

FIG. 5

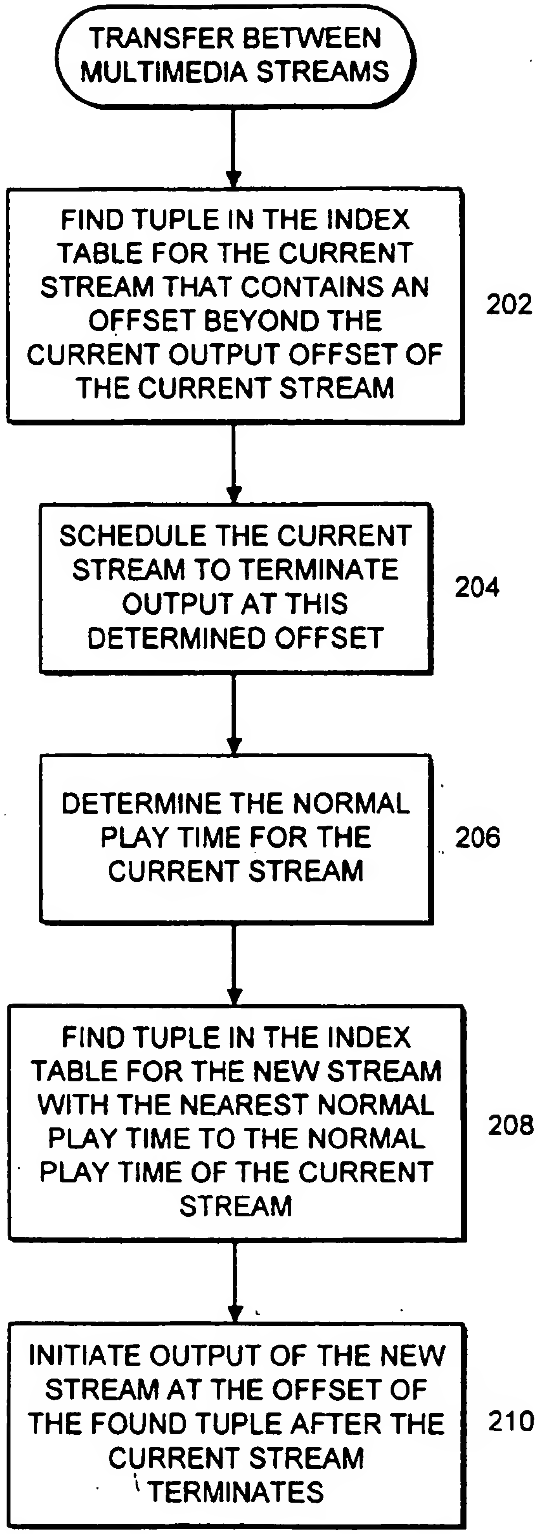
TRANSFER BETWEEN MULTIMEDIA STREAMS
FIND TUPLE IN THE INDEX TABLE FOR THE CURRENT STREAM THAT CONTAINS AN OFFSET BEYOND THE CURRENT OUTPUT OFFSET OF THE CURRENT STREAM
202
SCHEDULE THE CURRENT STREAM TO TERMINATE OUTPUT AT THIS DETERMINED OFFSET
204
DETERMINE THE NORMAL PLAY TIME FOR THE CURRENT STREAM
206
FIND TUPLE IN THE INDEX TABLE FOR THE NEW STREAM WITH THE NEAREST NORMAL PLAY TIME TO THE NORMAL PLAY TIME OF THE CURRENT STREAM
208
INITIATE OUTPUT OF THE NEW STREAM AT THE OFFSET OF THE FOUND TUPLE AFTER THE CURRENT STREAM TERMINATES
210

FIG. 6